HOW TO USE A GALVANIC BATTERY

DR. TIBBITS

THIRD EDITION

RÖNTGEN

G. B. TULLIDGE, M. D.

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HOW TO USE A GALVANIC BATTERY IN MEDICINE AND SURGERY.

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GALVANIC BATTERY IN MEDICINE AND SURGERY

A Discourse

DELIVERED BEFORE THE HUNTERIAN SOCIETY.

BY

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THIRD EDITION

REVISED, AND INCORPORATING

THREE LECTURES UPON ELECTRO-THERAPEUTICS

DELIVERED BY THE AUTHOR AT THE NATIONAL HOSPITAL

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NOTE TO THE THIRD EDITION.

This Discourse was first published in compliance with the request of several of those who heard it delivered, and who expressed to me an opinion that busy practitioners might perhaps be glad to have at hand, and in small compass, such information as it contained. It was obviously impossible to do more in so limited a time than to make a general reference to the therapeutic uses of electricity; and the most that I attempted in this direction was to recall to the recollection of my audience those conditions of disease in which the application of electricity would seem—without doubt—to be required; and to indicate the methods of application most generally useful. The construction of apparatus can not be understood from verbal or written description alone; and I appended to the text certain notes, and illustrations of the instruments which I submitted to the Society.

With the Second Edition I incorporated three Lectures which I delivered at the National Hospital for the Paralysed and Epileptic; and to this Edition I have appended such additional matter as I believe will prove useful to the student.

I may add that I have endeavoured, as was said by a deceased physician, "to paint electro-therapeutics not imperfectly, but, as it were, in miniature:" and that while I have carefully revised every page, and have noticed all real improvements introduced to the profession since the First Edition, I have kept the book a small book: and I venture to hope a book easily to be understanded by the multitude of practitioners who ask daily what instruments to use, and when, and especially how, to use them.

These questions I have endeavoured to answer in the following pages, which contain such details, and such details only, as I believe it essential for the practitioner to master.

68, Wimpole Street, W.
December, 1885.

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HOW TO USE A

GALVANIC BATTERY IN MEDICINE AND SURGERY.

LECTURE I.

ELECTRICAL INSTRUMENTS.

Mr. President and Gentlemen,

When your Council did me the honour to ask me to bring before you the subject of Electro-therapeutics, I felt that the invitation was addressed rather to the Hospital to which I am attached than to myself, seeing that to it belongs the merit of having been for some years the pioneer and outpost, so to say, in this metropolis of the scientific and methodical application of electricity to the alleviation and removal of disease; and that we are indebted to one of its distinguished physicians for a remarkable investigation into animal electricity, and the demonstration that much of what we have been accustomed to attribute to a "vital principle" may, in reality, be the effect only

Preliminary Remarks.

Preliminary Remarks.

of electrical charge and discharge* (a valuable contribution to the correlation of the Physical Forces); and to my predecessor for the discovery of the special influence of voltaic currents in certain forms of paralysis.†

As it is one of our objects in our practice here to study the scope and the limits of electricity as a remedy in disease, it seemed to me not inappropriate to devote my first Lectures to electro-therapeutics; and the more so, as few medical men have a practical knowledge of the subject; and I fear that the profession generally, through lacking this practical knowledge, are to some extent responsible for the utter and astounding recklessness with which the laity—ever ready to rush in where physicians fear to tread—are prone to apply painful and dangerous electrization, not to themselves, but to their suffering friends; while it is still too common for the medical practitioner (as quoted by Golding Bird upwards of forty years ago) to consider that when his fiat has gone forth "let the patient be electrified," he has done all that is necessary, while the patient usually carries out this mandate by the purchase of a rotary

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* See "Vital Motion as a Mode of Physical Motion." By C. B. Radcliffe, M.D. Macmillan.

† See Mr. Netten Radcliffe upon the differential reaction of voltaic and induced currents of electricity. Note to page 331, vol. i., of Bazire's translation of Trousseau's "Clinical Medicine." Hardwicke.

magneto-electric machine, and by using it according to the directions of its maker, who is generally about as well fitted to teach its application in disease as is the maker of an amputating knife to operate with it! Preliminary Remarks.

The almost complete absence in the medical schools of the great hospitals of opportunities for an adequate study of electro-therapeutics, the importance of the subject, and the widespread attention that it is awakening throughout the profession, have also determined me to sketch as briefly as is consistent with clearness the present position of the science and practice of medical electricity, and especially of its practice.*

Electricity, Gentlemen, is by no means one of those remedies that, failing to do good, is little likely to do harm. On the contrary, in injudicious hands, it is potent for evil, while the benefit to be derived from it is in exact proportion to the judgment and care with which it is administered. Moreover, the results of its employment are dependent, more than with any other therapeutic agency, upon the methods by which it is applied—methods that should be familiar, not alone to a few specialists, but to every practitioner.

* This observation, made in 1873, requires some qualification now (1886). At several of the great medical schools, though not at all, electrical treatment has been transferred from the hospital porter to some member of the hospital staff; and at more than one a systematic course of lectures upon electro-therapeutics has been delivered.

Preliminary Remarks.

Addressing you who are engaged in active practice, with little time to devote to medical electricity, it will, I think, be more acceptable for me not to weary you with a tedious discourse upon the elementary principles of electricity, for the practical application of these matters concerns rather the instrument-maker than the medical practitioner, and I shall discuss none of them, except incidentally, and *with precise reference to their application to medicine.* Besides, we know little of them, and I cannot forget that Faraday said that "he once thought he knew something about electricity, but the more he investigated it the less he found he understood it." Let us then be content with its definition as a "FORCE," "pervading all nature, latent in every substance, and liable at any moment to be excited by mechanical or chemical means."

Nor do I propose to make these Lectures in any sense exhaustive, but, on the contrary, to include in them only such information as is essential, and such as you may readily, and without effort, retain in your memory. I shall direct especial attention to practical points which are of importance to the successful use of electricity; for from non-observance of small details of application many failures have resulted, the treatment getting a measure of discredit, which in *strict justice* should have attached only to the operator.

In the present Lecture I shall consider instruments, their construction and management, a dry subject, but an essential one, the first requisite of a good workman being complete familiarity with his tools, lacking which he will be the victim of constantly recurring annoyances and difficulties; for although the present position of electro-therapeutics is largely due to improved methods of administration, these methods would be impossible with faulty instruments, while, on the other hand, the most perfect instruments require a certain amount of skill and care in their management, and some acquaintance with at least the mechanical details of their construction; and without this rudimentary knowledge it is also impossible to usefully compare one instrument with another.* Preliminary Remarks.

My second Lecture will be devoted to the different methods of applying electricity, and my third and last to its uses in the diagnosis and treatment of disease.

We make use of three varieties of electricity in medicine. Varieties of Electricity.

Firstly, of static or friction electricity, the electricity of glass and amber, appropriately called from its early investigator, *Franklinism*.

* I speak feelingly upon this matter, for from an early period of my electrical experience I have suffered much from batteries—from instruments "striking work" at the most inconvenient moment—from spilling of corrosive acid upon fingers and clothing, to the detriment of both, and of temper too, I fear.

Varieties of Electricity.

Secondly, of the electricity of chemical action, *Galvanism*, or better, *Voltaism*, the "*Constant Current.*"

Thirdly, of *Faradism*, the induced currents of momentary duration, which are generated or *induced*, in a coil of wire by the action upon it, under certain circumstances, of a magnet, or of a Voltaic current.

FRANKLINISM.

Franklinism, sometimes of the utmost value, and far surpassing, in certain cases, any other form of electricity, has some inconveniences in its application, and has hitherto been little used but by specialists. Recent improvements in Franklinic instruments have, however, largely removed these inconveniences, and have placed at the general service of the profession a remedy of much good and still greater promise. The fundamental requisite in all Franklinic machines, consists in the rotation of a glass plate against a leathern or other rubber, and the accumulation of the resulting electricity upon a metallic receiver, insulated by a non-conducting support, usually of glass.

Discarding the primitive cylinder machine, now long since disused, we will firstly consider the plate machine in which the electricity arising from the friction of the rotating glass plate against

the upper and lower cushions, is collected by two brass arms and distributed to the brass conductor, from which they branch out, and which is insulated by a glass support. Franklinism.

Fig. 1.

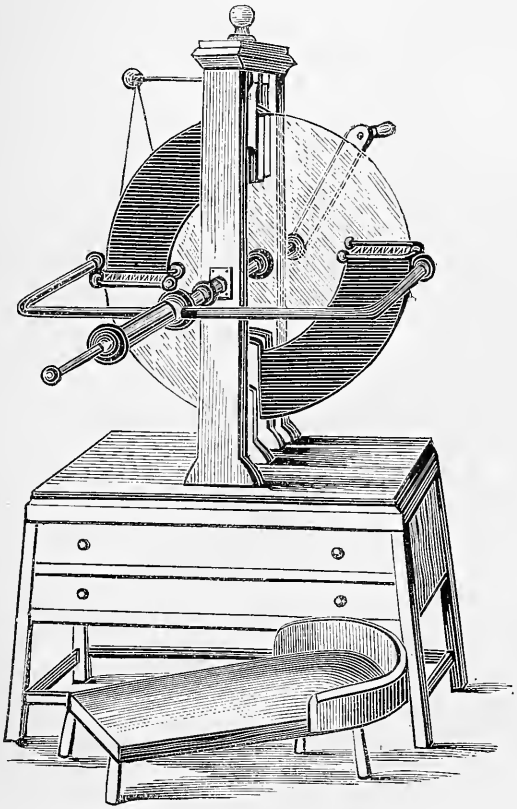


Plate Electrical Machine and Glass-legged Stool.

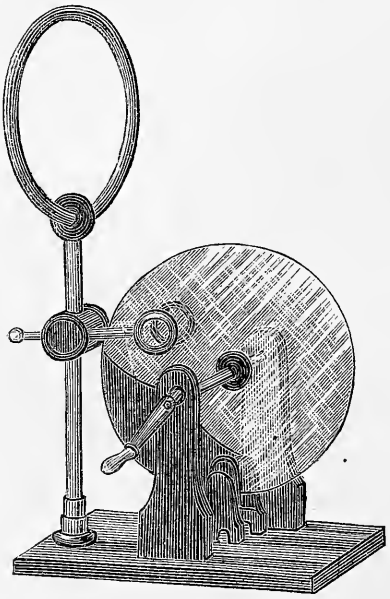
The machine should be fixed upon a firm stand that it may be quite steady during rotation, and

Frank-linism.

be screwed to a heavy painted deal table, as is shown in Fig. 1.

When very seldom used, *and where expense is a consideration*, very *fair* results may be obtained from a Winter's machine with a plate of only 15 inches in diameter, and which is easily carried.

Fig. 2.



Winter's Machine.

In this instrument, Fig. 2, the fact that the quantity of electricity which may be accumulated upon a conductor is dependent upon its size has been most ingeniously applied, the surface of the conductor being enormously increased by the insertion into a large wooden ring of a core of thick

iron wire. Electricity accumulates upon the wire, and is prevented from escaping by the insulating wooden covering. Franklinism.

But in the daily or frequent use of Franklinism it is essential, equally for the comfort of the operator, as for the benefit of the patient, that the most efficient apparatus should be provided. The one delineated in Fig. 3, and which I habitually use, is that known as Carrè's, but I have modified it by having attached to it a second accumulator, or conductor (the first time, I am led to understand, that such an improvement has been added to any such machine). This arrangement admits of the patient receiving the charge of either positive or negative electricity—a condition said by some physicians to be of primary importance.

There are other machines, but I do not propose to weary you with their descriptions.

When *any* Franklinic apparatus is in use its plate or plates should be evenly and uniformly rotated, and it is much better to have this done mechanically rather than by a man or maid-servant.

I use a "Bischoff's" gas engine, shown to the right hand in Fig. 3. It consists of a cylinder, surmounted by a hollow column serving as a guide to the piston. From the extremity of this column there is a very long connecting rod which acts upon the crank of the shaft of the fly-wheel and

Franklinism.

driving-pulley. When the piston ascends it draws in during four-tenths of its course a mixture

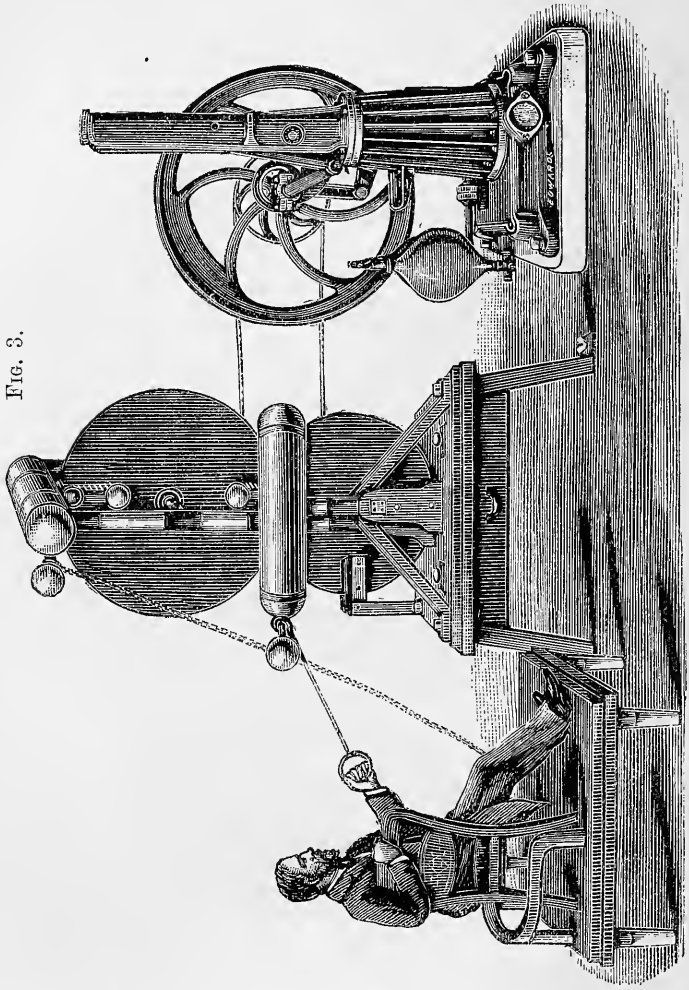


Fig. 3. Static Machine with Gas Engine and Insulating Stool.

of air and gas from the pipes. A little before the piston has ascended half-way a gas jet ignites the

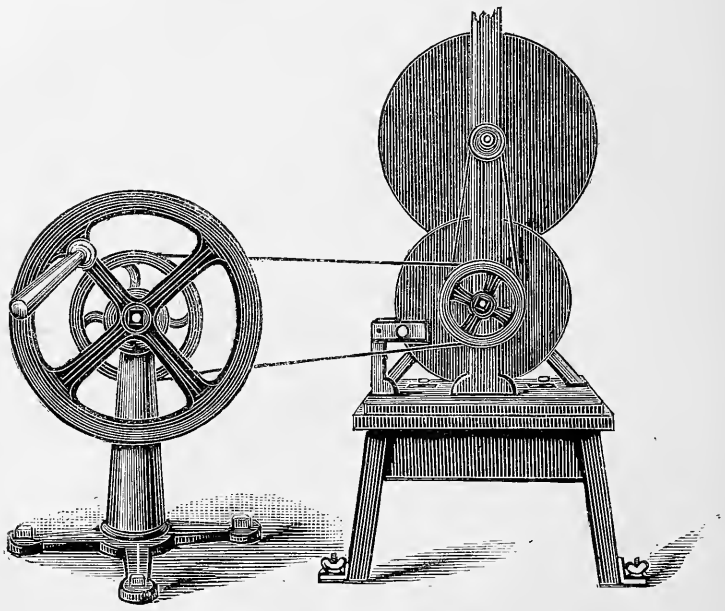
mixture. There is a slight explosion without the least effect on the sides of the cylinder, but sufficiently strong to push the piston and cause it to complete its course. In consequence of this movement the piston is raised and acts on the connecting rod, forcing it upwards and half turning the fly-wheel. On account of the speed acquired, and of the impulse given, the fly-wheel continues its course by means of the crank and connecting rod, and sends the piston to the starting-point again. Then it ascends again, taking in a fresh charge of air and gas, motion being imparted anew to the driving shaft by every revolution of the engine. Franklinism.

An engine of 2-man power, with an altitude from the ground to the top of the column of 4 feet, and with a fly-wheel measuring 2 feet 6 inches in diameter, is amply sufficient for every purpose. It works evenly and without noise; it is absolutely free from danger, and it is placed instantly in or out of action by merely igniting or extinguishing a single gas jet. But it is remarkable that no one seems to have suggested—even before the gas-engine era—that a "fly-wheel" with a pulley would obviate the old difficulty of the unsatisfactory rotation of the Plate machine. Going into a hair-cutter's shop I found the apparatus, figured to the left of Fig. 4, standing in the shop to work the customary "hair brushing machinery" instead of its being, as is usual, fixed upon an upper floor. I

Frank-linism.

obtained one, and fitted it in the manner shown, to a Carrè's machine. The fly-wheel is so heavy that it can be rotated by the operator without the aid of an assistant, by his giving the handle an occasional "swing round." Its momentum then keeps it revolving a sufficient number of times before the

Fig. 4.



Fly-Wheel and Static Machine.

next "swing" is required, to enable him to leave it and attend to his patient. The manner in which the band from it is attached to a small wheel in rear of the Static machine is also shown in the Figure.

In Fig. 3 the patient is being "charged" with *positive* electricity, or, as the electro-therapeutists of fifty years ago would have said, "he is taking an electro-positive bath," by being insulated and connected through the metallic rod held in his hand with the accumulator upon which the positive electricity is stored, while the negative electricity is "run off" by a brass chain leading from the negative accumulator to the ground. If the process were reversed, the positive accumulator, being connected with the ground, and the patient with the negative one seen at the top of the machine, he would be taking "an electro-negative bath;" for we make him, as it were, a part of each accumulator as the case may be; its accumulated electricity passes to him and he becomes *charged.* If the air were perfectly dry he would continue (as he is insulated) in this charged condition, but owing to its contained moisture the electricity rapidly leaves him, and to maintain the charge it is necessary that the plate of the machine should be kept in constant rotation. Indeed, the escape of electricity is so rapid that to get the best action we must have a fire in the room, and before use well rub the plate, the insulating supports, the legs of the stool, and all the glass parts of the apparatus with a warm and dry piece of flannel. This is of importance, and however dry the day, should as a rule never be neglected. Franklinism.

Frank-linism.

By smearing the inside of the cushions of the machine with a little paste, composed of an alloy of mercury and tin (technically known as "amalgam"), mixed with a little tallow, the amount of electricity is much increased, but care should be taken not to smear the cushions with too much, which had better be bought ready prepared. A piece about the size of a small grape for each of the cushions will be enough, and no more need be added for two or three weeks. Always scrape off old amalgam before adding new. The cushions should be screwed sufficiently tight to slightly "grip" the plate, and if it is found that notwithstanding having rubbed the glass of the apparatus as above directed, the instrument is not supplying a sufficient quantity of electricity, remove the cushions and warm them thoroughly. *It is impossible to be too careful that everything is warm, clean, and dry,* for the great obstacle that exists against the extended use of Franklinism is found in this difficulty sometimes present, from neglect of the above precautions, in getting efficient action. But even on a foggy day the instrument, *with proper care,* may be made to act well. The operator should also remember that dust must be sedulously guarded against. A few drops of petroleum may be sprinkled upon the table, and their vapour condensing upon

the machine will aid in protecting it against moisture.* Franklinism.

There will also be needed two or three lengths of brass chain, or of copper wire, and a stool about 4 feet by 2 feet, with four glass balls or legs. A stool of this size admits of a chair being placed upon it, as in Fig. 3, and it will be also useful for certain applications of voltaism, which will be

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* So long ago as 1870, I was in the habit (at the suggestion of Dr. Radcliffe) of employing at an Institution for Resident Patients, a method of "charging" a patient which I believe to be unique.

Unique method of charging a patient.

During dry summer weather the patient reclined upon a couch in the gardens insulated by glass supports, and a sort of lightning conductor was improvised by attaching a 30-feet salmon-rod to the foot of the couch, a piece of ordinary "telegraph wire" being carried up the rod, its insulation being removed from about a foot which projected above the top of the rod.

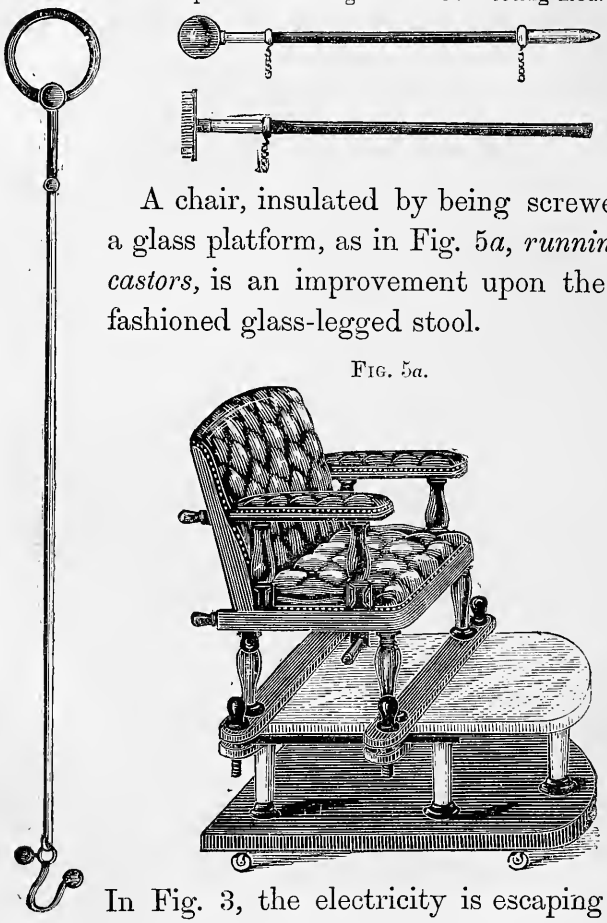
Upon a fairly warm and dry day the patient became "charged" and sparks could be drawn from him as from a patient in ordinary connection with a Franklinic machine in rotation.

Upon more than one occasion in those ancient Static days, an attempt was made to insulate a patient for a whole night, and to maintain the charge by a relay of "rotating nurses;" but the *human machines failed*, and suitable gas engines were not then available; hence the procedure related above was, if conducted for three or four hours on a dry summer afternoon, a by no means bad substitute for a close room and a rotating Static machine. In New York, in winter, when the rooms are covered with thick carpets, and when the atmosphere is dry, it has been known that on shaking hands with a visitor, not only has the "shock," which under similar circumstances occasionally occurs in England, been felt, but that a spark has passed; and children have been known to slide over the carpet towards each other and exchange sparks by way of sport. *The influence of atmospheric and other ordinary electrical conditions has been far too little studied by electro-therapeutists.*

Franklinism.

mentioned later on. Four glass jars are also needed with which to insulate an ordinary couch.

Fig. 5. Improved Dischargers and Connecting Rod.



A chair, insulated by being screwed to a glass platform, as in Fig. 5*a*, *running on castors*, is an improvement upon the old-fashioned glass-legged stool.

Fig. 5*a*.

Franklinization by Sparks.

In Fig. 3, the electricity is escaping from all points of the skin, but if it is desired to localize somewhat this escape along the course of certain nerve branches, or otherwise, but to avoid shock,

a brush may be slowly passed by the operator almost, but not quite, in contact with the skin. A series of rapid and successive reunions of the electricity with each bristle of the brush takes place, generating a current of cold air perceptible to the patient. I habitually use for this application an ordinary clothes-brush. If while in connection with the conductor any object (the knuckles will do) is brought sufficiently near to the patient for his contained electricity to overcome the resistance of the intervening stratum of air, he is "*discharged*" with a spark. This is *Franklinization by sparks*, and is accompanied by a certain slight amount of "shock." Franklinization by Sparks.

In Fig. 6, improved "dischargers," and a convenient metallic connecting rod are shown.

The ball terminations of the dischargers should vary in size, for within certain limits, the larger the ball the more intense the spark; with the pointed end the spark is very small; with the discharger terminating in many small metallic points still smaller, and with a similar discharger made of wood, a luminous glow alone results, and no spark.*

I shall discuss, in my third Lecture, the therapeutic values of Franklinism.

* The Carré Machine can be obtained from Mr. Groves, 89 Bolsover Street; the Fly Wheel from Messrs. Hovenden and Co., Great Marlborough Street; and the Gas Engine from Messrs. Andrew and Co., Engineers, Stockport.

VOLTAISM OR GALVANISM.

Voltaism.

The Voltaic current is a *continuous* current. Unless artificially interrupted, the electricity flows in an unbroken stream until the battery is exhausted. The current will gradually lessen in power until it ceases, but there will be no break in it, and no change in its direction, which is uniformly from the positive to the negative pole. It is important to recollect these points, for they constitute the chief physical distinction between the Voltaic and the Faradaic—or, as it is sometimes called, the Induced current. This latter is not, strictly speaking, a "*current*," but a rapid discharge or succession of momentary shocks, each perfectly distinct in itself, and separated by an appreciable interval of time from its fellows.

Points of distinction between the Voltaic and Faradaic Currents.

Voltaic Cells.

In electrization, a source of electricity is of course necessary, and this is furnished by a cell or cells, with contained elements and chemicals; and, until a few years ago, it was impossible to get a *portable* cell that remained always in order and ready for use.*

Requisites of a Portable Battery.

The requisites of a portable battery are that it should be really portable, always ready for use, and little liable to get out of order. Such batteries may be divided into two classes: firstly,

* Currents of electricity from large fixed batteries are most marked in their curative effects; but patients are not always movable!

Requisites of a Portable Battery.

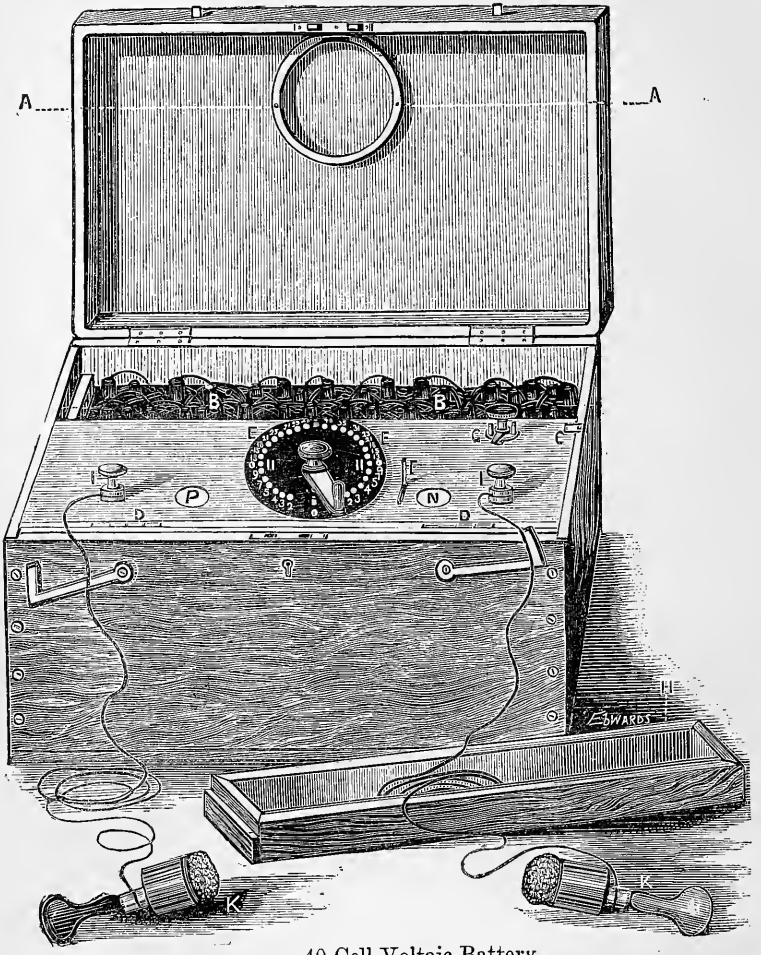
those in which the elements are either lowered into the exciting fluid or the fluid is lifted to them, as in the instruments of Stöhrer, Weiss, and almost all other makers.; and, secondly, those in which the elements remain immovable in their cells, and of these the Leclanché, the Gaiffe-Clamond, and the chloride of silver, are to be generally preferred to any of the first-named construction, for they admit of the cells being so nearly sealed up that no fluid can be spilt by any movement except turning the battery quite upside down; while the somewhat common accident with batteries of the first-named construction—viz., destruction of the plates by leaving them in the acid, with its anything but agreeable result of a considerable expense to replace them, is obviously impossible. The only disadvantage they possess is that when exhausted it is necessary to send them to the maker to be recharged, *while the owner can keep the first-named variety in order himself.*

Efficient cells are, however, but a first step to the perfection of electrical apparatus, and the mechanism by which the current is brought into use and graduated, and the general accessories of the instrument, are of at least equal importance. The instruments which I am about to describe, have been designed by myself, and may be obtained from Mr. Hawksley, Surgical Instrument Maker, Oxford Street. It is claimed for them that they

The Voltaic Battery.

place at the service of the busy practitioner a battery that with ordinary care (and no instru-

* Fig. 6.



40-Cell Voltaic Battery.

A. Guard preventing the lid being shut, unless the needle of the dial points to "0", and the instrument is out of action.

ment will remain in order without this) may be kept upon his consulting-room table, always as available to his service as his stethoscope or ophthalmoscope. The Voltaic Battery.

Three kinds of batteries are constructed:— A Voltaic battery, with any required number of cells, from 15 to 100; a Faradaic battery; and a Combined battery, uniting both Voltaic and Faradaic currents.

*The Voltaic Battery** (see Fig. 6, p. 20) has its cells arranged in the interior of a mahogany case, and in use they are hidden from view and from danger, but I now partially expose them by removal of the tray for holding the sponges and accessories. Their connecting wires are brought across the under surface of the element board, which is made to move upon hinges that, when necessary, the cells may be

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B. Cells shown by the removal of the compartment, H, for sponges and accessories.

C. Bolt to secure the element board, which moves upon the hinges, D.

D, D. Hinges of element board.

E. Dial plate regulating the strength of the current. The needle, when the battery is not in use, should cover the stud, "0," seen to its left.

F. Commutator of the poles. The poles, N and P, are seen through holes cut in the element board.

G. Key by which the current can be shut "off" or "on," without change of position of the conductors. It can also be used by vibrating it backwards and forwards as an "interrupter."

I, I. Binding screws, to which are attached the conducting wires and sponge-holders, &c.

The Voltaic Battery.

examined, but at other times this element board is held in position by a bolt, and it should never be needlessly disturbed. These wires conduct the current through the graduating dial, and the position of the needle of this dial determines from how many of the cells the electricity shall be allowed to reach the binding screws, and from them, by way of the conductors, sponge-holders, or electrodes, the body of the patient,* or whether

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The Galvanometer as an aid to the Dosage of Electricity.

* *The Galvanometer as an aid to the Dosage of Electricity.*—The dose of voltaic electricity is made up of two factors, (*a*) the strength of the current and (*b*),the time during which it is applied to the patient. The strength of the current is directly dependent upon the number of cells employed, but, unfortunately, cells of dissimilar construction evolve currents of very unequal strength; while cells that have been freshly charged are more powerful than similar ones that have been partly exhausted by use; and, therefore, to speak of a current from "so many cells," though, practically, a convenient method of dosage, fails to convey any *exact* idea of a measured and unvarying quantity. It is a comforting theory to electro-therapeutists that a galvanometer will enable them to administer their doses of electricity with as much exactitude as we daily prescribe so many grains, or so many minims of ordinary medicines; but, like some other theories which save us much trouble, when adopted as theories *only*, it fails us in practice (at least according to my experience), and chiefly so, because a galvanometer can be usefully employed only when it is included in the circuit of a continuous current, as, *e.g.*, in aneurismal electro-puncture; and, I believe, I am within the mark in saying that electrizations, which even admit of its useful employment, are indicated in barely 5 per cent. of ordinary cases in electro-therapeutics; and that it is of no practical utility, where we most want aid, in measuring, not the current which leaves the battery terminals, but that which, after overcoming the very variable resistance of the human skin, really reaches the underlying muscular and nervous tissues, which, in 95 per cent. of our cases, we desire to influence, not by a constant, but by an interrupted Voltaic current; and the amount which really reaches these tissues

it shall be entirely shut off, as is the case when the battery is not in use, and when the needle stands at "0."* When the needle points to any

The Voltaic Battery.

depends largely upon the condition of the patient's skin, and, I may also add, upon the kind and shape of the conductor, and its degree of moisture, &c.; and the operator will do well to graduate his dose of electricity by a consideration only of the three factors, number of cells, effect upon himself, and effect upon his patient, discarding entirely the use of any merely mechanical aids to graduation.

The Galvanometer as an aid to the Dosage of Electricity.

I am induced to speak thus strongly because men of scientific reputation have advocated the habitual use of the galvanometer, not alone by medical men trained to precision of observation, but by private patients as "*enabling them to carry on the treatment at home with all the accuracy desirable!*" The prospect of the ordinary patient provided with a battery, the use of which he is complicating by a galvanometer, is anything but reassuring to those physicians who not only prescribe electricity, but are themselves habituated in applying it—which, by the way, is a very different thing—and who have had frequent experience of the manner in which patients misunderstand, or fail in correctly carrying out, the most explicit directions. Electricity will be left in the hands of specialists, and necessarily do but a tithe of the good it is capable of affecting, until the mass of the profession can be induced to master the few preliminary details essential to its successful application, and I fear that the suggestions that have been made—suggestions which I believe to be entirely without foundation—that there exist practical difficulties to its dosage, will tend to postpone rather than to accelerate its more extended use.

Should any of you desire to use a galvanometer, that patented

* Fig. 7.

Graduating dial with needle at "0".

The Voltaic Battery.

stud numbered on the dial, the number of cells marked on that stud are brought into action, and the needle is made just wide enough to touch one of the studs before it breaks contact with the preceding one, and thus the current may be increased or decreased in power without shock, and while the electrodes are held applied to the patient; but if it were not so made a series of painful shocks would be communicated whenever the current was increased or decreased. Should

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The Galvanometer as an aid to the Dosage of Electricity.

by Sprague, of Birmingham, is the one most adapted for use in medicine. Electricity is a force, and as with other forces it has its standard of measurement. In mechanics we know that the power sufficient to raise one pound to the height of one foot is the basis of measurement. Similarly in electricity the unit of measurement is the force which will raise one gramme to the height of one metre, and the standard multiple of this was called a "British Association Unit," or shortly, a "B.A." unit, and it is now called an "*Ohm*" when used to measure the resistance offered to the current, and a "*Veber*" when used to measure the strength of the current itself. The ordinary galvanometer is founded on the principle that a magnetic compass needle has a tendency to place itself at right angles to a current of electricity, and the degree to which the needle is deflected is a measure of the quantity of electricity, but the angle of deflection is not proportionate to the current strength, and it differs in different galvanometers; but in "Sprague's Galvanometer" the dial is divided, not into degrees, but into divisions of thousandths of *Vebers*—divisions which were obtained by noting the deflections given by the needle with currents of known strength. I am indebted to Mr. Sprague for his courtesy in endeavouring to so modify his galvanometer as to render it available as a graduator of doses of interrupted Voltaic electricity, but although he has not succeeded in doing this, he has constructed for me an instrument which, supposing that a battery be partially exhausted, will indicate with precision the absolute strength of, say, twelve of its cells as compared with twelve newly-charged cells, and also the condition of each individual cell, points often of much practical convenience in an Hospital Electrical Room.

the needle, from forgetfulness, be left when out of use in any other position than at "0," a guard upon the lid of the instrument prevents its being shut, and the operator has his attention called to his inadvertence. A Voltaic alternative, or change of direction of the current, is sometimes required in treatment, and the commutator of the poles enables this to be accomplished without alteration in the position of the conductors. By pushing forwards or backwards the handle which moves a lever working below the element board the current is instantly reversed, and the alternation of the letters "P" and "N" seen through holes cut in the element board indicates at once not only that there has been a change of poles, but which pole is at the moment negative or positive; whereas in all previous instruments, when the poles have been changed, there has either been no letter marking them, or this letter has really been wrong, and one has had to remember this; and under such circumstances, and examining patients in rapid succession, momentary confusion of the poles was very liable to occur, even to a practised operator. A key enables the current to be shut off or on without removal of the conductors. Dirt is a non-conductor of electricity, and the studs of the dial must be kept clean with emery paper or plate-powder, as also the under surface of the needle, key, and binding

The Voltaic Battery.

screws, which unscrew to admit of removal. In the daily use of a battery the chief work is usually thrown upon the first half (say in a battery of forty cells, upon the first twenty-five), and various arrangements have been added to batteries by ingenious instrument-makers to enable the operator to vary his selection of the cells to be brought into use, and thus to relieve the first half of his battery, or, in other words, to equalize its work. But this unequal work question is more a theoretical than a practical evil ; for if the initial cells grow weaker a greater number can be placed in use. I have carefully studied all the proposed modifications, and have found in all of them the remedy worse than the disease, unless the graduating dial be doubled (an original suggestion of my own), so that the initial cells of one week may be made the terminal cells of the next.

When desired batteries can be constructed with this double dial,* but it adds to the com-

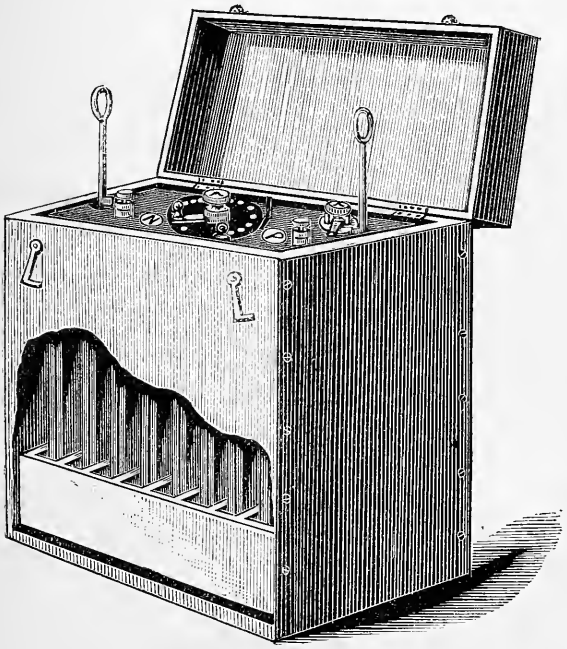
* Fig. 8.

New form of Graduating Dial.

plexity of the instrument, and I do not myself use it. The Voltaic Battery.

In Fig. 9 a similar battery is shown to that just described ; but the elements consist of carbon and zinc, and are lifted into and out of a bichromate

Fig. 9.



40-Cell Voltaic Battery with zinc and carbon elements, and lifting apparatus.

solution. As it can be recharged by the owner without the necessity of sending it to the maker, it is especially suited for country and colonial practitioners.

Essentials of a Medical Voltaic Battery.

To recapitulate. The essentials of a medical Voltaic battery are—

a. A constant supply of electricity of sufficient quantity and quality.

b. A means by which this electricity may be administered in measured doses.

c. A means by which the direction of its current may be changed.

d. A means by which it may be instantly discontinued.

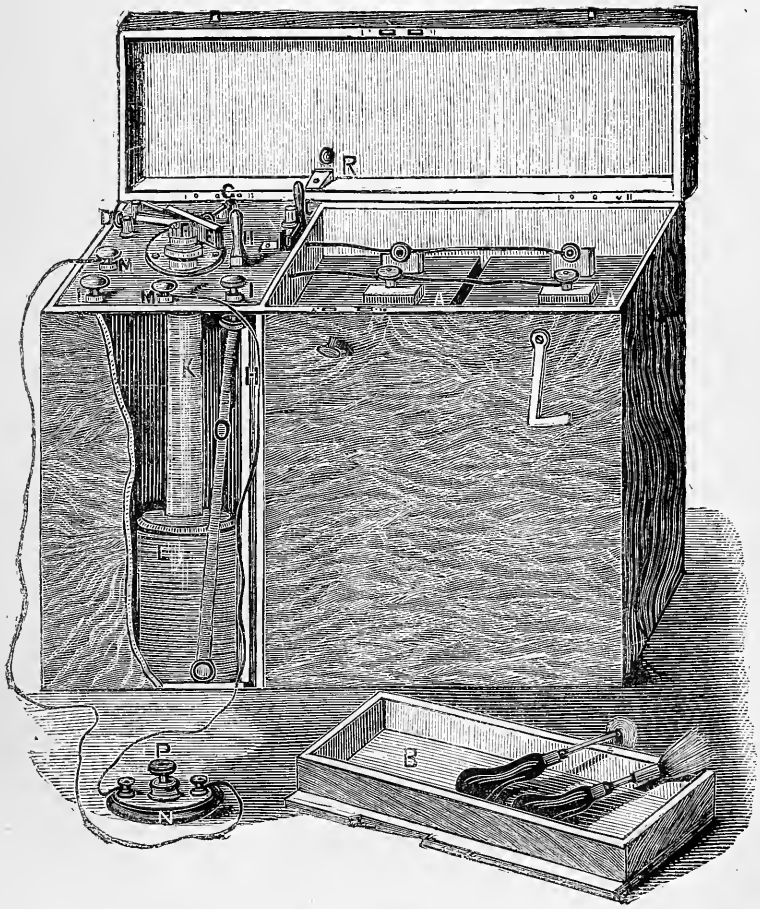
FARADISM.

The Faradaic Current.

The Faradaic, induced, interrupted, or electromagnetic current, is the third form of electricity employed in medicine. Faraday, as you will recollect, discovered, that if two metallic wires were so fixed as to be parallel and close to each other, but not to touch; and that if then a current of Voltaic electricity were sent along the first wire, another current appeared in the second. This *secondary* or *induced* current, as it is called in contradistinction to the current, the *primary* or *inducing* current sent along the first wire is only momentary, but it appears again for a moment when the first current ceases, but in a reverse direction. It is most convenient to wind these two wires round two reels, so as to form separate coils, and to place the primary within the secondary coil. Each single turn of the primary then acts not only on

the parallel turn of the secondary wire, but on all the turns near it, and the power of such an ap- The Faradaic Battery.

* Fig. 10.



Faradaic Battery.

A. Cells shown by the removal of the compartment.
B. for conductors and accessories.

The Faradaic Battery.

paratus is much greater than that which would be obtained by the same lengths of wire running side by side in a straight line. Our two coils being thus arranged, we pass through our primary wire a succession of electrical currents, and in practice this is accomplished by connecting its extremities with a battery supplying a continuous current, which by an ingenious mechanism we frequently break or interrupt.

*The Faradaic Battery.**—In Fig. 10 (see p. 29),

D. Screw regulating the pressure of a spring which modifies the vibration of the hammer, E.

E. Hammer vibrating between the electro-magnet, F, and the point of a platinized needle regulated by the screw, G.

F. Bundle of iron wires rendered an electro-magnet by the passage of the Voltaic current from the cells, A, through the primary coil, K, within which this bundle of wires is inserted.

G. Screw regulating position of a platinized needle.

H. The graduator, a stem to which is attached the movable secondary coil, L. The front part of the case has been cut away in the engraving, to show the construction of the induction apparatus.

I, I. Binding screws for attachment of the conducting wires, &c.

K. The primary coil, fixed upon a pedestal. In the figure, the secondary coil, L, is wholly withdrawn from the action of the primary, and its strength of current depending entirely upon the extent to which it covers the primary, it is evident that the height which the graduator, H, stands above the element board will exactly indicate this strength.

L. Movable secondary coil.

M, M. Binding screws for attachment of the pedal rheotome, N, for slow interruption. These interruptions are made by the pressure of the operator's foot upon the spring, P, but in practice they are very seldom wanted, and the fittings are only added to the instrument when specially ordered.

O. A spring retaining the secondary coil, L, in any desired position.

a Faradaic battery, worked by two Leclanché cells, is shown; but I find it better to employ either one or two ordinary bichromate cells instead of the Leclanché, as the former can be kept in order by the operator himself without much trouble. The primary coil is fixed upon a pedestal, the secondary is movable, and can be lifted over or thrust away from the primary. The degree of action in the secondary coil being proportionate to the extent to which it is brought under the influence of the primary, this arrangement admits of the most perfect graduation of the current; and it has been for some time in use in all well-constructed instruments. The innovation I have made consists in limiting the primary coil to its legitimate purpose of induction, and rendering the secondary alone available for application to a patient. I have been long satisfied that therapeutically the distinction between the primary and secondary coil entirely consists in the greater tension of the current of the secondary coil enabling it to penetrate easily several thicknesses of muscle, but there is no therapeutic indication that cannot be fulfilled by this secondary coil; and at its lowest power I have frequently applied it to the conjunctiva. The rapidity of vibration of the interrupting hammer is varied by increasing or decreasing the distance between the point of the needle and the electro-magnet by the protrusion or retraction of

The Faradaic Battery.

The Faradaic Battery.

the screw, of which the needle forms the end—that is, by increasing or decreasing the space through which the hammer passes in its vibration, and also by altering the pressure of its spring, but there is seldom therapeutic need for change of vibration; and unless this exists it is better *not to alter the adjustment so long as the instrument acts well.** After considerable use the point of the needle, and the exact spot of the platinum disk of the hammer against which this needle impinges, become oxidized, causing weakening or stoppage of the current. This platinum disk has been constructed to rotate, and a hole has been drilled in its circumference.† By inserting a little lever furnished with the instrument into this hole, the slightest twist given to the disk is sufficient to bring a new surface of platinum into contact with the needle point. This will usually be all that is required, but, if not, the needle can be unscrewed, and its point cleaned with emery paper. When in course of time the disk

* A little care is needed to regulate the vibrating needle. The spring should but *barely touch* the hammer, the adjustment being almost entirely regulated by the protrusion or retraction of the needle by the action of its screw; and the *slightest twist* of this screw will be sufficient. When the vibration is uneven or stops, and careful manipulation of the needle fails to re-establish it, remove the needle and clean its point as directed in the text.

† Fig. 11.

The Platinum Disk and Lever.

becomes dotted over with spots of oxidation, the screw fixing the hammer in position must be unscrewed, the hammer lifted out, and its surface similarly cleaned. The Faradaic Battery.

Induction currents are also produced in coils of wire by the action upon them under certain conditions of a permanent magnet—as in the ordinary rotary magneto-electric machine—but these machines may be discarded from our consideration, for they are uncertain in action, painful in application, and do not admit of exact graduation.

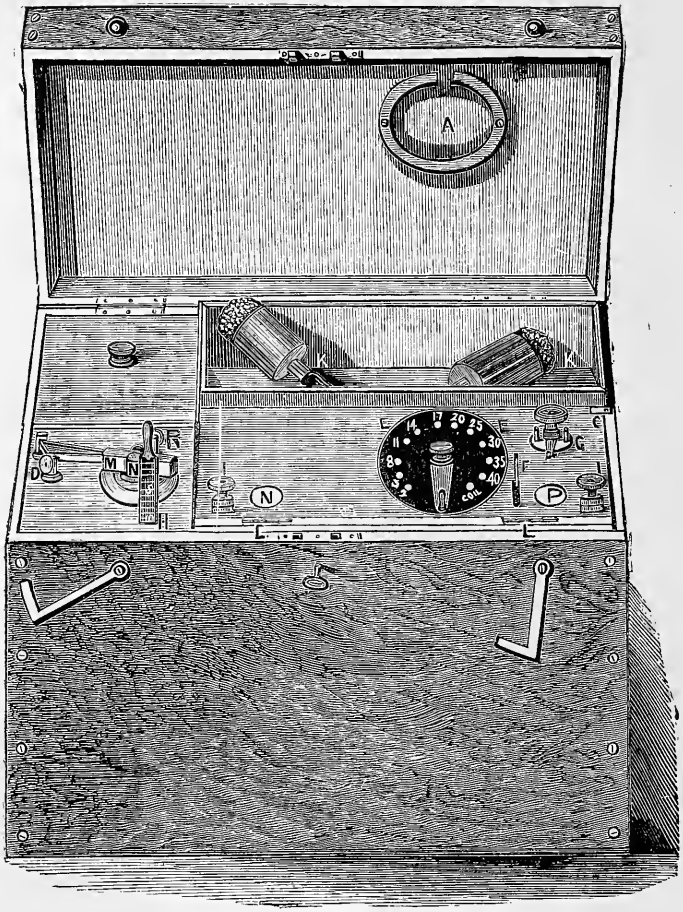
An apparatus in which both currents are combined is extremely convenient if it is so constructed that either the Voltaic or Faradaic current can be brought to the same terminals, thus avoiding the trouble of changing the conductors—a point of the greatest possible convenience when examining patients for diagnostic purposes by both forms of electricity, either in succession or alternately.

In the *Hospital Combined Battery* (see Fig. 12), constructed from my designs, the two currents are thus united, and its details are precisely similar to those of the separate batteries, with the exception of the Dial being furnished with an additional stud lettered *Coil.* When the needle points to this stud the current from the Faradaic coil is brought into action; when it points to the numbered studs, the cells numbered thereon as in my Voltaic in- The Hospital Combined Battery.

The Hospital Combined Battery.

strument, and when it points to "0," both currents are shut off.

Fig. 12.



Hospital Combined Battery.

A. Guard block.
C. Bolt securing element board.
K. Tray for holding accessories.
G. Key for interrupting current.
E. Dial plate.
M. Hammer.

Other instruments, such as those of Stöhrer and Weiss, are excellent, and were unsurpassed until the invention and improvement of the Leclanché and other cells. But I might talk upon instruments for hours without exhausting the list; and I have felt obliged to limit myself to a description of those I believe best fitted to our requirements; but it, of course, must be understood that my further *observations will apply equally to currents of electricity furnished by any properly constructed and reliable apparatus.*

The Hospital Combined Battery.

We have now brought the electricity to the terminals of our battery, and we must next consider the best means of conveying it to the sponges, conductors, or, as they are generally termed, rheophores or current carriers, by which it is finally applied to our patient. Our first necessary accessory is a conducting cord or wire, and it is of the first importance that this should really be what it is called—"*a conductor*"—for any fault or break of connection in it will, of course, nullify the best and most perfect battery. It must also be sufficiently pliable, and be insulated by being coated with some non-conducting material that the electricity may not escape from it to any con-

Accessories of the Battery.

Conducting Cords.

F. Commutator of the poles.
I, I. Binding screws for conducting wires.
L, L. Hinges of element board.
H. Graduator of coil.
N. Electro-magnet.
R. Screw regulating position of needle.
D. Screw regulating spring of hammer.

Conducting Cords.

ducting substance with which it may accidentally come into contact. The conducting cords sold by instrument-makers are sometimes not insulated at all, and then they are quite useless, but they are more commonly composed of several strands of metallic wire of about the diameter of sewing thread, the whole enclosed in some silken or woollen material, and nothing can be better than these latter when quite new. Their disadvantages are that they become frayed after a little use, and are liable to be constantly out of order, causing interruptions in the current, while they will only fit one kind of machine. I have had endless trouble with them; and for some years I have used nothing but thin copper wire, coated with gutta percha in the same way as that known as "telegraph wire." This is perfectly insulated, sufficiently pliable for all practical purposes; it is cheap, and can be made to fit any sort of connection. Its one disadvantage is, that it is liable to break at the point where it is received into the terminals of the battery, or the screw socket of the rheophore. Should this happen, all that is necessary is to scrape off the gutta percha coating with a pocket knife for an inch from the broken end, by which we get practically a new conducting cord.

We have now considered fully the birth and parentage of medical electricity, and we have con-

ducted it to within almost a hair's breadth of our patient. The various methods of applying it will be considered in our next Lecture, which I trust, Gentlemen, to render more interesting; but the dry details we have been discussing are, I assure you, essential as a secure foundation for a practically useful survey of electro-therapeutics.

Conducting Cords.

LECTURE II.

METHODS OF APPLYING ELECTRICITY.

GENTLEMEN,

Résumé of First Lecture.

In our first Lecture we studied the different kinds of electricity employed in medicine, and the construction and management of batteries. I reminded you that we made use of three kinds of electricity; firstly, of friction or static electricity, *Franklinism;* secondly, of the electricity of chemical action, *Voltaism*, or *Galvanism;* and, thirdly, of induced electricity, *Faradism:*—that there had been certain difficulties in the employment of Franklinism, but that these difficulties no longer existed; that Voltaic electricity was electricity in motion, or current electricity, but that while its current (unless artificially interrupted) was always *continuous*—flowing, that is, in an unbroken stream—and from the positive to the negative pole, until the battery was exhausted—it by no means followed that it was *constant,* that is, that it did not vary appreciably in power during application; that only batteries supplying a fairly constant current were fitted for medical use, and that all others should be rejected. We then considered different batteries, both fixed and portable; that while large fixed low tension

batteries were unquestionably superior in their therapeutic effects, patients unfortunately were not always movable, and that a portable battery became, therefore, a *sine quâ non;* that portable batteries might be conveniently divided into two classes, one in which electricity was generated by the elements being immersed in an exciting fluid only during actual use, and being taken out of the fluid immediately after use; and the second that in which no removal of the elements was necessary; that the Voltaic current was graduated into doses by some arrangement determining the number of cells to be employed in each case, but that this method, while practically useful and sufficient, failed to convey an exact idea of a measured and unvarying quantity of electricity; and that it had been contended that by the use of a galvanometer, doses of electricity might be as accurately administered as so many grains or minims of ordinary medicines, but that, perfect as the theory might be, I had personally failed to obtain help in practice from a galvanometer; that next in importance to a method of dosage, was it to be able to instantly change the direction of the current, or to at once turn it "off" or "on," in addition, of course, to the fundamental requisite of a continuous supply of electricity of sufficient quality and quantity. Résumé of First Lecture.

We next considered the induced or *Faradaic*

Résumé of First Lecture.

current, so-called, which I reminded you is not a current at all, but a rapid discharge or succession of those momentary shocks, each perfectly distinct in itself, and separated by an appreciable interval of time from its fellows, which Faraday discovered to be generated or induced by a Voltaic current flowing along a wire in other wires parallel to, but separated from, the first wire; that by winding the two wires upon two movable reels and introducing one within the other, not only might these *secondary* currents be multiplied indefinitely in proportion to the number of spirals of wire, but by introducing or withdrawing the one from within the other an exact method of graduation was afforded us. I pointed out to you that there was no therapeutic distinction between the so-called primary and secondary currents, and I recommended you therefore to use only the currents of the secondary coil. I then showed you the construction of Faradaic instruments, and of instruments combining both Voltaic and Faradaic currents, and our survey was completed by a consideration of the different varieties of conducting wires or cords, and my recommendation of thin gutta-percha covered copper wire as generally superior to any other form. We have to-day to study methods of applying electricity, and to learn how to use the instruments, with the construction and properties, of which I trust you are now

familiar; and, Gentlemen, it is well worth your while to have obtained this knowledge, for its possession will not only enable you to readily rectify any faults in the working of your batteries, but the necessity of sending them to the instrument-maker may be often avoided. Résumé of First Lecture.

We have already studied methods of applying Franklinism.*

Voltaization and Faradization may both be applied either generally—as in the different forms of electrical baths—or locally.

A convenient method of applying electricity, when very strict localization is not required, is to insert the feet and hands of the patient, or one foot and one hand, as the case may be, in separate vessels containing tepid salt and water with which the conducting wires of the battery are in contact, the current being allowed to circulate during the time required. Ordinary foot-pails, basins, or jugs, will fulfil every requirement; while thick telegraph wire answers well to connect the battery with the vessels of water, as it is little liable to break and wears well. A variety of the constant current (originated by Dr. Radcliffe) is very readily applied in the way just described, with the addition only of some means of insulating the patient and the accessories, and of a length of The Application of Electricity.

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* See pages 6–17.

Radcliffe's Positive Charge.

ordinary uninsulated copper wire. Dr. Radcliffe believes that an administration of *positive* Voltaic electricity, somewhat analogous to the charge of Franklinic electricity, is frequently beneficial. He insulates the patient and the accessories, and having connected the negative pole with the earth by a wire which he calls a "ground-wire," he allows the current to pass. With careful insulation the negative electricity passes away by the wire, and while the current circulates the patient continues "charged" with positive electricity. There must be two wires from the negative pole, one to be applied, as well as the positive, to the patient, and the other taken "to earth." This latter may be conveniently attached to a chandelier or gas-pipe, which always gives a direct metallic conduction to the ground. A perforated vulcanized indiarubber mat, or a sheet of gutta percha, or a glass-legged stool can be employed to insulate the patient and the accessories.

The Electric Bath.

There is another generalized application which has been much advocated, and remarkable statements have been put forth, not only of its curative power in almost every disease, but also of its purely physical and chemical effects—I refer to that by "Electric Baths," several establishments of which exist in London, but you need not send your patients to them. You can teach them how

to take an electric bath in their own bed or bath-room. A bath sufficiently large for the patient to recline in it should be insulated by glass supports (four stout tumblers will do very well), and filled with water at a temperature of 95 to 100 degrees. A metallic plate in connection with one pole may be inserted at the head, and a second plate in connection with the other pole at the foot of the bath. The patient should be protected from direct contact with either plate by sitting upon a wooden framework. With a sufficiently powerful current, a portion of the electricity will pass through the body of the patient reclining thus between the poles. Another method is to connect the water with one pole, and for the patient to grasp in his unimmersed hands a copper bar covered with wet flannel, and in connection with the second pole of the battery; or a conductor from this second pole may be held almost, but not quite, in contact with any part of the body immersed in the water. Either the Voltaic or Faradaic current may be used. Ordinary water with the Faradaic current, but salt and water, or acidulated water, with the Voltaic.

The Electric Bath.

Another more generalized application is that introduced by Beard and Rockwell, under the name of "General Faradization." The patient sits with his naked feet upon a sheet of copper connected with one pole, while the other pole is connected

General Faradization.

General Faradization.

by a moistened sponge with the left hand of the operator, who passes his disengaged hand, slightly moistened, over the muscles of the patient, and sometimes over his whole body. The current, I need hardly say, passes through the body of the operator before it reaches the patient, and the sensation he feels is his chief guide to its graduation.

Centralized Galvanization.

Another general application is the "Centralized Galvanization" of the same authors, in which their object is to bring the whole central nervous system under the influence of the Voltaic current.

They place one pole—usually the negative—at the epigastrium and pass a large moistened sponge from the positive pole over the forehead and top of the head, along the inner border of the sterno-mastoid, from the stylo-mastoid fossa to the sternum, and down the entire length of the spine, from the nape of the neck to the sacrum. The brain, sympathetic and spinal cord, and the pneumogastric nerves are thus submitted to the influence of the current.

Localized Electrization.

But the great majority of cases require—not a generalized, but a strictly localized application, and for the fundamental principles of all methods of localized electrization we are indebted to the late Dr. Duchenne (the "father of electro-therapeutics"), for before him no one had attempted any local application of electricity that could

properly be so called. Indeed, to Duchenne may be fairly ascribed the very birth of medical electricity as a branch of therapeutics, and in the true and kindly words of the *Lancet*, when announcing his death:—"No field of work was ever seized upon with more eagerness; ever cultivated with more earnestness; or perhaps ever made to yield a better harvest than that which the discovery of induced electricity placed at the disposal of the man whose genius was the first to recognize, and his talents to secure, the opportunity it afforded. Taking his work at its lowest estimate, he was a man to whom medical science owes a large debt of gratitude, and whose memory deserves a warm tribute of regard." Duchenne's two test experiments, demonstrating the fundamental principles of his method, I will now repeat upon the posterior surface of my left forearm. I propose to arrest Faradism in the skin, without allowing it to stimulate the subjacent muscles. To do this it is necessary for the skin to be quite dry—moisture, as you know, being a conductor of electricity—and to make sure of sufficient dryness, I sprinkle the skin with a little starch powder. I now apply to the dry skin the dry metallic conductors of an induction instrument in action. I am afraid you cannot see, Gentlemen, the small sparks produced as the two electricities combine upon the cutaneous surface, or hear the slight crackling sound pro-

Localized Electrization.

Localized Electrization.

duced, but you observe no muscular contraction, and what I feel is a superficial and evidently cutaneous sensation. I now replace the dry conductors by well-moistened sponges. You observe that I have not altered the power of the current, but that there is energetic contraction of the extensor muscles. This is quite involuntary, and is due to the electric irritation of the branches of the motor nerves.

It follows from these experiments that we may, at pleasure, arrest electricity in the skin, and that without puncture or incision we may make the current traverse the skin, and concentrate its action upon subcutaneous organs. It was at one time objected that the muscular contraction was the result—not of irritation limited to the muscle or its motor nerves—but of reflex action; but Duchenne demolished this objection by a vivisection. Having removed the skin from the face of a living rabbit —to whom chloroform had been administered—he divided the facial nerve of one side only, in order that the muscles supplied by it might be cut off from all connection with the cord. He then applied electric excitation to each muscle of the face, alternately, on the two sides. The muscles contracted separately and equally on both sides. He then destroyed the brain of the same animal, in order to place the cord in a condition favourable to the production of reflex action, and again excited

the muscles as before. The results were absolutely the same.* Localized Electrization.

Muscular electrization may be produced either—as I have just shown you—by placing the conductors upon the muscle itself, a procedure termed *direct* or *intra-muscular* electrization, or by exciting only the motor nerve trunk, which is termed *indirect,* or *extra-muscular* electrization, and which we shall consider presently.

For direct excitation of the larger muscles it is convenient to use well-moistened sponges, contained in cylinders of different sizes, or metallic disks, covered with wet leather and having conveniently shaped handles. A useful size of cylinder is one such as this (see Fig. 13), having a depth of about $1\frac{1}{2}$ by $1\frac{1}{8}$ inches, which allows the sponge to fairly fill it, while in such forms as this—6 inches by 1—when the sponge is inserted the lower three-fourths of the cylinder is empty, and the conduction of the current liable to become imperfect. Such a cylinder as this, without any insulating handle at all, is worse than useless, and is a still persisting relic of the barbarous time when the patient was invariably electrized by causing him to hold the conductors one in each hand, a proceeding extremely dangerous in certain patholo- Different kinds of Rheophores.

* See Duchenne (de Boulogne) "On Localized Electrization and its Applications to Pathology and Therapeutics" (English Edition). Part I., pp. 38–40. London: Churchill.

Different kinds of Rheophores.

gical conditions, and in other cases not likely to be of benefit to him. The insulating handles should be well hollowed out, that they may be used, lying comfortably between the fingers, when holding two in the same hand. The disk rheophore (see Fig. 14), a metallic button covered with wash-leather, is extremely useful; it has the advantage over the sponge of allowing firm pressure to be made without the inconvenience of water being squeezed out, while by using its edge it may be made to answer in the majority of cases for a pointed conductor, which is fitted chiefly for application to very small muscles, such as the interossei and some of those of the face. The wire is attached to the conductor by being screwed into the socket (see á, Fig. 14). A conducting cord is very apt to get frayed at the point of

Fig. 13.

Cylindrical Sponge-holder.

juncture, and that the wire which I recommend is not open to this objection is not the least of its advantages. In direct electrization the rheophores should be firmly pressed down upon all points of the surface of the muscle, that all of its fasciculi may be equally electrized. With the Faradaic current it is convenient to apply the rheophores, held in the same hand (see Fig. 15), for from twenty to thirty seconds, to every part of the surface of the muscle, or group of muscles, promenading them as nearly as may be in lines from the origin to the insertion of the muscles. If the rheophores are not held in the same hand care should be taken to keep them near to one another, for the tension or penetrating power of Faradism is so great, that without this precaution there will be liability to excite reflex

Different kinds of Rheophores.

Direct Electrization.

Fig. 14.

Metallic Disk, covered with Wash-leather.

Direct Electrization.

action. With the interrupted Voltaic current this liability does not exist, and a better plan when using it is to hold the sponge from the positive pole stationary, near to the origin of the muscles, and to stroke or paint as it were the entire muscular surface with the sponge from the negative pole, gliding it in lines from the position of the positive. In using the constant Voltaic current both sponges must be held quite immovable, and so applied it differs altogether in its effects from the very same strength of current interrupted by moving the conductors. I will demonstrate these different applications upon the extensors of my left wrist and fingers—Faradism—Voltaism—Constant Current.

Indirect Electrization.

Indirect, or extra-muscular electrization, next claims our attention. You will recollect that it is produced by acting upon the special nerve trunk and its branches, instead of by placing the rheo-

Fig. 15.

Method of holding Sponge-holders with Sponges inserted.

phores upon the muscle itself. We may thus call a motor nerve into action without affecting the cutaneous nerves, and with a minimum of power of current, and necessarily a minimum of sensation which hardly ever need amount to actual pain. This method is preferable, therefore, in cases where we desire to produce muscular contraction and as little sensation as may be, and again when the sedative influence of the constant Voltaic current is required to be localized in any special nerve. In its application it is convenient to place a good-sized sponge connected with one pole upon an indifferent part of the body, such as the sternum, and to apply a pointed conductor from the second pole directly over the course of the nerve it is desired to act upon. Speaking generally, these motor points as they are called may be selected by reference to a good anatomical plate, but only approximately, for we know that it is common to find variations in the course of the nerves and in the mode of their distribution among the muscles, and this being so, it is well when we propose to act upon a motor or mixed nerve (which is not paralyzed), to make sure that we are localizing the current in it by producing for a moment the contraction of its muscles and then marking the spot by touching it with a pencil of nitrate of silver. This, of course, is only necessary where in our subsequent electrization we do not

Indirect Electrization.

Indirect Electrization.

wish muscular contraction, as in the treatment of neuralgia.* I will demonstrate indirect electrization by Faradizing the median nerve in my left forearm above the wrist, and before it passes beneath the annular ligament of the carpus. It lies a little below the surface, between the tendons of the flexor carpi radialis and palmaris longus. You observe that its muscles powerfully contract and oppose the thumb to the other fingers, at the same time abducting it. There occurs also a slight flexure of the first phalanges of the index and middle fingers. Professor Zeimssen in his work on Medical Electricity has published some extremely accurate plates of the motor points of the body, and I have grouped together the more important of them in a chart or map for convenient reference.† Ziemssen's method of pro-

Importance of exactitude in administering a constant current.

* It is often of imperative importance in the administration of the "*constant*" current that we should really localize it—not in name only, but in fact—in some special nerve; and this is not always quite so easy in practice as in theory. To secure the result we desire, we must see that the cord or wire from the terminals of the battery to the electrodes is without flaw; that the electrodes are well moistened and placed firmly in the position determined upon; and especially that they are held quite immovable during the entire application, for if not maintained immovable, we shall be using not a "constant" but an "interrupted" current with totally dissimiliar physiological and therapeutical effects! We must satisfy ourselves that the current from our battery is also constant, and that we so apply it to our patients that the affected nerve shall be—as it is called—included in the circuit—that is, between the poles, and that the current circulates through this nerve as perfectly and continuously as it would through a piece of wire connecting the terminals of the battery.

† Published by Churchill.

cedure was to find out experimentally the points where the application of electricity most readily produced muscular contraction. He then marked these points with coloured chalk, and after a sufficient number of trials with nitrate of silver. Photographs of the parts thus marked were taken and afterwards transferred to the wood blocks. These figures may therefore claim to be true to Nature, although they may not be absolutely correct for every individual. Ziemssen verified their appoximate exactitude by following the course of the nerves very accurately in the dissecting-room and observing their points of entrance into, and their course within, their muscles, with constant reference to the surface of the body; but he was not completely satisfied until he had determined the motor points upon the skin immediately after death, and before the reaction to electricity had disappeared, and submitted these points to the scalpel. The results of the three methods coincided perfectly. Indirect Electrization.

We will next consider cutaneous electrization. I have already shown you that when the skin and the conductors are both quite dry, a Faradaic current of moderate power (and practically this form of electricity is always employed in cutaneous electrization) does not penetrate the skin, but is localized upon its surface. There are three methods of applying cutaneous Faradization—the Cutaneous Electrization.

Cutaneous Electrization.

method that we employed—that of "*Metallic Conductors*;" the "*Electric Hand*," as it is called, in which the operator having applied one conductor to some little sensitive part of the patient's body, holds the second in his left, and passes the back of his right hand over the points he wishes to excite, these points of the patient's skin and the back of his hand being dry, and sprinkled with absorbent powder; and the "*Wire Brush*," a brush of metallic wire, which replaces one of the conductors, and which is moved over the skin. With a strong Faradaic current this wire brush becomes the most powerful of all the excitants of the skin which do not disorganize its structure; in fact it was proposed by some scientific parliamentary philanthropist as a substitute for flogging in the navy, and I have no doubt that more intense pain may be produced by it than by any application of the cat, however well laid on!

Electrization of Internal Organs.

The methods of electrizing internal organs need not detain us long. The rectum and muscles of the anus may be electrized by introducing into the rectum the rectal rheophore, a metallic stem insulated by gum elastic, and moving it over the internal surface, bringing it also into contact with the levator and sphincter ani. A well-moistened sponge connected with the other pole may be applied to the abdominal muscles or to the neigh-

bourhood of the anus. The rectum must be first freed from fæcal matter. Electrization of Internal Organs.

The bladder is most readily electrized by the introduction into the rectum of the rectal rheophore, and into the bladder—previously emptied—of a curved metallic sound insulated by an elastic catheter to within an inch of its vesical extremity. This sound must be brought into contact successively with all points of the neck of the bladder. The uterus by the introduction of the rectal rheophore, connected with one pole, to the os uteri, and by the application of two sponges from the other pole, one to the abdominal parietes, the other to the lumbar region. The larynx, externally by one sponge to the nape of the neck, and the second to the exterior of the larynx; or, internally, a sponge to the neck as before, and the introduction by the aid of the laryngoscope of a small bit of sponge at the end of a curved metallic stem, insulated by a gum-elastic catheter, the current not being allowed to pass until it is seen by the laryngeal mirror that the sponge is in the desired position. The male genital organs by moist rheophores to the scrotum over the testicle; but if it be desired to excite the vesiculæ seminales, the bowel is first emptied, the rectal rheophore is then introduced and so directed that its olive-shaped termination may be brought into relation with the vesiculæ. For this purpose it is sufficient to move the rheo-

Electrization of the Central Organs.

phore from right to left and *vice versâ*. A powerful current will penetrate the intestine and reach the vesiculæ, exciting them energetically. The circuit is completed by a second rheophore placed on an unsensitive part of the body.

In electrization of the central organs of the nervous system, the Voltaic current is alone used, and in its application to the brain, the sympathetic nerves, or the organs of the senses, especial circumspection must be employed. As a general rule it should not be had recourse to when central excitement is contra-indicated, and in *all cases* the minimum dose should be commenced with, and the application discontinued upon the occurrence of giddiness, nausea, or cerebral symptoms. With these precautions the brain may be electrized by well-moistened sponges applied to each mastoid process, to each temple, or to the frontal and occipital protuberances. The sponges must be held immovable. To galvanize the superior cervical ganglion of the sympathetic, one electrode of small size must be deeply pressed into the auriculo-maxillary fossa, and the other with a good-sized sponge applied over the sixth or seventh cervical vertebra, or to the manubrium sterni, close to the border of the sterno-mastoid. The spinal cord may be electrized by keeping one sponge, usually the positive, stationary, and moving the other up and down by the sides of the

vertebræ, or one pole may be applied to the spine, and the other held to a nerve or muscle. The retina by a moistened conductor to the closed eye, and the second to the temple or to the mastoid process of the same side. The auditory nerve by one conductor tipped with sponge and inserted to the bottom of the meatus, the second being held in the hand of the opposite side; or the meatus may be filled with tepid water, and a metallic wire traversing the axis of a vulcanite tube may be immersed in the water, the second conductor being a well-moistened sponge to the nape of the neck. Direct application to the ocular muscles or to the conjunctiva is usually inadmissible, but one pole may be placed over the facial nerve below the ear, and the other applied to the closed eyelid, or the operator may use the forefinger of his right hand, covered by a finger-stall of wet linen as an electrode, passing the current through his own body by holding a moistened sponge from one pole in his left hand, the conductor from the second pole being similarly held in one of the hands of the patient. This application is not only convenient, but it is calculated to allay the fears of a sensitive patient: or a pointed conductor, covered with wet leather, may be connected with one pole, and its point held immovable and firmly pressed down upon the orbital margin, as near as possible to the position

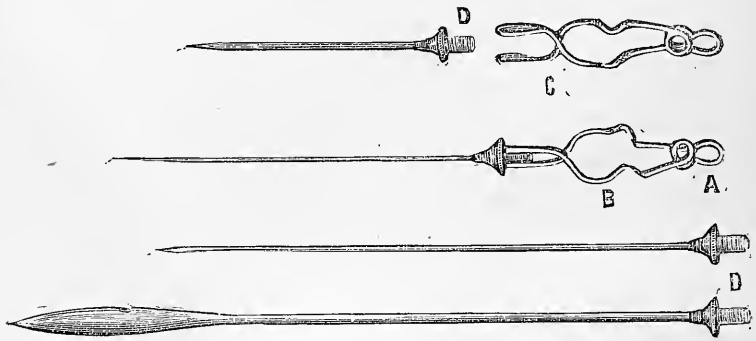
Electrization of the Central Organs.

of the muscle it is desired to excite, while the patient touches at intervals the sponge from the second pole held by its insulating handle in the operator's disengaged hand.

Electrolysis Needles.

The chemical action of a continuous Voltaic current is sometimes useful in the removal or dispersal of tumours, and in the consolidation of aneurisms, one or more needles being introduced into the tumour, and connected with a Voltaic battery. I shall discuss this subject in our next Lecture, but I have here some of the most generally useful needles,* and I have had made for them holders with eyelet-holes for the attachment of conducting wires which render the operator independent of special conducting cords, for with a coil of insulated wire and a pocket knife he can

* Fig. 16.



Electrolysis Needles and Needle-holders. By pressing the spring side B, the holder opens as shown in C, to grasp the needle D. The wire is twisted into the eyelet hole-A.

fit up his needles in a few minutes in any way best adapted to his proposed operation.

Having now considered the more generally useful methods of application, it may perhaps not be out of place to remind you in concluding this part of our subject that certain precautions are necessary to be observed. We must keep constantly before our attention that we are prescribing or administering an exceedingly powerful remedy, and with all new patients we should commence with a minimum dose, watch its effect, and if we need to increase it, do so gradually—*e.g.*, muscular contraction being sought we must use the power just sufficient to produce it and *no more*—and so on with other applications; and it is especially necessary to use care in applying the Voltaic current to the face, neck, or any part of the head. Duchenne blinded a patient by suddenly applying a current from 40 cells to the facial muscles, and he had the candour to publish his misfortune. Sudden applications and sudden cessations should especially be guarded against. The cessation shock can, of course, only occur in cases where the conductors having been held immovable, and the current gradually increased, one or both of them has been abruptly, and it may be inadvertently, removed; and I have known a patient so frightened by such a cessation shock as to decline further treatment. The negative pole of a Voltaic battery will, if fre-

Precautions in mode of Application.

Precautions in mode of Application.

quently applied to the same spot, soon cause a sore, and to avoid this the point of application should be slightly varied occasionally; and let me impress upon you, Gentlemen, the importance of always testing electricity upon yourselves before applying it to a patient. Use as many galvanometers, or so-called "instruments of precision," as you like, but use in addition the back of your left hand as a convenient approximate test for the Voltaic, and your thumb muscles for the Faradaic current, except when about to apply electricity to your patient's head or face, and make it then an invariable rule to first apply to your own face the same strength of current you are about to administer to your patient's. If you authorize your patient to have treatment carried out at home impress this rule upon whosoever electrizes him. Under such circumstances it is especially imperative, for there is great belief, even with educated persons who ought to know better, that the benefit derived from electrization is in exact proportion to the pain given by it, and a little personal experience is a very wholesome corrective to such a notion. Graduate your dose, then, by the number of cells employed checked by testing its effect, and do this upon each application, for there is no certain means of securing that the strength of either a Voltaic or a Faradaic current shall not have varied from day to day.

Precautions in mode of Application.

We have now studied, Gentlemen, medical electricity, electrical instruments, and methods of application. In our next and concluding Lecture I propose to discuss the assistance that electricity affords us in diagnosis, prognosis, and treatment.

LECTURE III.

ELECTRICITY IN DIAGNOSIS AND TREATMENT.

A.—*Electricity in Diagnosis.*

GENTLEMEN,

Electro-Diagnosis.

Our first two Lectures were devoted to a consideration of electrical instruments; the different varieties of electricity; and the most approved methods of applying them in therapeutics. To-day we have to study their uses in diagnosis, prognosis, and treatment.

The chief use of electricity in diagnosis is dependent upon its power of evolving muscular contraction. We have seen—as I demonstrated to you upon my left forearm—that both muscles and nerves, when in a normal condition, respond to

Test of Electro-Irritability.

the stimulus of electricity. In disease this response, or irritability, may remain unaltered, or it may be increased, decreased, or abolished; and our first step in electro-diagnosis should therefore be to ascertain the exact condition of electro-contractility. As in practically almost all our cases we have to do with altered reaction existing only in one nerve or muscle, or in one of two

symmetrical groups of nerves or muscles, we possess a ready means of testing irritability by ascertaining its relative condition upon opposite sides of the body, as, for example, in an ordinary case of hemiplegia. In examining such a case electrically—and the principles of procedure are the same in all cases—it is convenient to commence our investigation with the Faradaic current, and to ascertain the *lowest* power which will call into action any one of the muscles of the healthy side, and then to apply this same strength of current *to identical points of the corresponding muscle on the diseased side,* noting whether it causes contraction. If so, we decrease the power of the current, when if contraction still occurs there is increased irritability, or *vice versâ*, as the case may be. Having ascertained the condition of the muscle we proceed similarly to test its motor nerve, for we shall see hereafter that in certain diseased conditions muscle and nerve irritability are affected unequally. One conductor being held to an indifferent part of the body we apply a fine-pointed conductor to the most superficial point in the course of the nerve, in the way that, as you will recollect, I electrized my left median nerve. We next submit the muscle and nerve to similar examination with the Voltaic current. Holding both conductors immovable, we interrupt the current for a moment by moving the "key" of

Test of Farado-Irritability.

Test of Voltaic-Irritability.

our battery, or if it is not provided with a key, while one conductor is stationary, we break the current by lifting and reapplying the other. It is essential that on both sides there should be exact similarity in the application, and that the electrodes should be placed on identical points of the muscle, and this is especially important with the Voltaic current, for healthy muscle responds to it more readily when it flows down the limb, that is, with the positive pole nearest to the spine, and the negative farther from it than when it flows up, and consequently a reversal of the poles will influence the result. In testing a case in which there is equal disease upon both sides—as in some cases of paraplegia—we must be guided by a knowledge of the strength of current usually required to induce contraction. As a general rule, unless a current that causes energetic and painful action in the muscles of the ball of the thumb produces some contraction, irritability is impaired. If, in our examination of the muscle, we find irritability normal to both currents, we have proof of the integrity of the muscular tissue. If the muscle also responds by contraction to electrization of its nerve, we have further proof that the nerve is healthy, and also the spinal cord at the point of origin of the nerve. If we find the irritability lessened, there is disease of either muscular tissue, nerve or cord; and, as a rule, this will be in direct

Rule for strength of Current.

Electro-Irritability diminished.

proportion to the amount of diminished irritability. Increased irritability points to increased vascularity or irritative lesion; but in such cases we very seldom require the aid of electricity to complete our diagnosis. The reactions of Faradism and Voltaism are usually equal, but in some cases in which muscular response to Faradism is diminished or abolished the muscular reaction to an interrupted Voltaic current is not only preserved but increased. The diseased muscle will respond much more readily to the Voltaic current than the corresponding muscle of the healthy side; while at the same time it will be found on examining the nerve that there is equal diminution to both currents. This increased muscle reaction is due to the special irritability of muscular tissue, and is quite independent of any nerve influence. It exists only in peripheral and never in central lesion, and by it we obtain an absolute diagnosis of such cases as local paralysis of the facial nerve from facial hemiplegia, paralysis of the extensors of the wrist and fingers, due to lead poisoning, from commencing muscular atrophy, or progressive muscular atrophy from paralysis from section of a nerve—all important questions as affecting treatment. It is known as the "degenerative nerve reaction," as it always follows when a nerve trunk is involved in the lesion. There is then diminution of Faradaic irritability through both nerve

Electro-Irritability increased.

Volta-Irritability increased

Diagnosis of Peripheral from Central Disease.

"The Degenerative Nerve Reaction."

and muscle, diminution of reaction to the Voltaic current when the rheophores are applied over the nerve, and increase of reaction when they are applied over the muscle; but there is no relation between these interesting variations in the electrical condition of nerve and muscle, and the degree of paralysis to the will, for there may be perfect muscular paralysis, as in hemiplegia, when the electrical condition of both nerve and muscle is unchanged; but, on the other hand, in muscles equally paralyzed we may find absolute electrical changes in some, and none in others. We may often positively predict that these latter will rapidly recover—one instance of the use of electricity in prognosis.

After long disuse of healthy muscles a slight degree of diminution of electric irritability may sometimes be present, but this is always restored by two or three Faradizations, and its existence is hardly likely to present any difficulty in diagnosis. With this qualification we find that in paralysis from brain disease electric irritability is normal, except when irritative lesion is present, and then it is increased. In paralysis from disease of the substance of the cord irritability is diminished, and this will sometimes aid us in the diagnosis—not always easy—between commencing paraplegia and locomotor ataxy. In ataxy—at least in its early stages—irritability is normal. In

Central Paralysis.

Spinal Paralysis.

progressive muscular atrophy it is normal as long as any muscular tissue remains. In hysterical or emotional paralysis irritability is normal, but electro-sensibility is often much impaired. These variations will sometimes enable us to distinguish between real and pretended disease; and, finally, absolute abolition of electric irritability in all the muscles of the body is proof positive of death, so that those extraordinary people who are haunted by a fear of being buried alive may rest contented if they provide that after apparent death, and before burial, their bodies shall be submitted to thorough electrical examination.

Hysterical Paralysis.

Diagnosis between Real and Feigned Disease.

Electricity as Proof Positive of Death.

Considered solely as an aid to diagnosis, we can get little more assistance from electricity than I have pointed out to you.

And now, Gentlemen, we come to the consideration of the last and most important branch of our subject—electricity as a therapeutic agent—its scope and its limitations as a remedy.

Is it needful for me to say that there is too much belief and too much unbelief in its therapeutic power?

Limitation of Electricity as a remedy.

The men who estimate it fairly are quite the minority. It is generally either much undervalued, or else believed to be a sort of modern "*Elixir Vitæ*," capable of curing a hopeless hemiplegia from destruction of brain tissue, or a paralysis agitans from senile degeneration. Although electricity

will do neither of these impossibilities, yet, considered as a remedy, it is of great value in a wide margin of diseases. It will either stimulate or soothe both nerve and muscle, according to its variety and mode of application; it will frequently restore voluntary movement, it will relieve pain, heighten temperature, recall sensation, coagulate the blood, and dissolve or slowly cause the absorption of tumours.

B.—*Electricity in Treatment.*

FRANKLINIZATION.

Franklinization as the oldest form of electricity and as partaking more of a general application than a local, may be conveniently considered first.

Administered by the various methods described at pages 6 to 17, it has been found in the practice of the National Hospital for the Paralyzed and Epileptic, and in private cases coming under my own observation, of considerable value. *Facial neuralgia,* for example, which has resisted other modes of treatment, may occasionally be relieved with rapidity and permanently by drawing sparks along the track of the affected branch or branches of the trifacial nerve. Sometimes also *obstinate sciatica* has been partially or altogether removed; so also *facial spasm* (tic convulsif), as in the following instance, for permission to quote which I am in-

Facial Neuralgia.

Sciatica.

Facial Spasms.

debted to Dr. Radcliffe. A female, forty-eight years of age, had suffered for thirteen years from spasm of the muscles of the left side of the face. The distortion produced by the spasm was very great, and was apt to be so much exaggerated by slight emotion, even such as would be caused by having to address a stranger, as to make speaking difficult, and to prevent proper attention to her occupation as a small shopkeeper. An experimental trial was made of electrization by sparks along the lines of the nerves distributed to the affected muscles. After the third application the spasm was manifestly relieved, the distortion being diminished, and the paroxysms occurring less frequently. By persisting with this treatment thrice weekly over a period of two months, so great an amount of relief was obtained that little distortion of the face remained, and the patient was able to pursue her business with comfort. Electrization by sparks over the larynx has been found so effective in the relief of cases of hysterical or *emotional aphonia*, even those of long standing, that it is well to use it in the treatment of these cases before having recourse to induced electricity. In six or seven recent cases, this form of application repeated twice or thrice effected a complete cure. One of these cases was of nine, another of six months' duration. The remainder had lasted from four

Emotional Aphonia.

weeks to three months. The seventh case did not receive any benefit from the use of static electricity, and the other forms of the agent proved equally ineffective. The case recovered slowly under general treatment. Electrization by sparks over the affected spot has often proved of great benefit in removing the *localized excessive sensitiveness* not unfrequently found in hysterical cases, particularly in the spinal region. *Tremor*, whether general or local, is sometimes largely relieved by insulating the patient, and charging him with positive electricity for a period of twenty minutes to half an hour. Other applications failing, I would advise always, in cases similar to the above, a fair trial, say half a dozen sittings, of Franklinization.*

Localized Excessive Sensitiveness.

Tremor.

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* Since writing as above, in 1873, our knowledge of the beneficial effects of Franklinism has been very largely added to and the improved apparatus, described at page 10, has enabled the treatment to be conducted with a degree of precision and success impossible with the comparatively imperfect instruments in use at that date. Dr. Radcliffe has contended for many years that the effect of a charge of *positive* electricity differs altogether therapeutically from that of a negative charge; and Giacomini (quoted by Duchenne†) attributes a hyposthenic influence to the *negative* charge. He contends that this charge is derived from the nerves of the patient instead of from the ground as is the positive charge, and it is ranked by the Italian School among their most valuable hyposthenisants. According to Giacomini the "patient is *de-electrized, is consequently deprived of a greater or less quantity of a stimulant analogous to heat and undergoes a real hyposthenisant effect.* Erysipelatous tissues may

Importance of distinguishing between the Positive and Negative Charge of Franklinism.

† See "Duchenne on Localized Electrization," English Edition, page 4. Churchill.

ELECTRIZATION.

Electro-therapeutics.

We have seen that if we send a shock of electricity through a motor nerve the nerve becomes excited, and responds by contraction of its muscles. One form of electricity, then, is a stimulant, but, unlike other stimulants, it admits of its action being exactly localized and its influence instantly withdrawn. There first results from

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be seen to become blanched under its influence, and chronic inflammations undergo an unquestionable improvement. Headaches and neuralgic pains have been instantly relieved by this kind of electric flux as by the application of ice, which abstracts heat, and perhaps at the same time electricity also."

In reference to the above it has been proved by various physicists that the natural electrical nerve current is strengthened by the positive charge, and weakened by the negative—and hence it would seem to be established that Dr. Radcliffe's contention is the right one; and that these two charges are literally "wide as their poles asunder" not only physically, but *therapeutically*, and this divergence is more important when we recall to mind that when a patient is insulated, not only does the electricity accumulate upon the surface of the skin but that the whole body is saturated with it as a sponge may be with water.

In my own experience the positive charge has been of great good as a most potent restorer when the organism from any cause has become enfeebled. In the general weakness of old age it would seem to have been beneficial upon several occasions in resuscitating vital action and in imparting new force and energy. I have also used it with the best results in conditions of debility following acute diseases, as for example in convalescence from fevers; in cases of general prostration from overwork or anxiety—and in some cases of phthisis and other wasting diseases. In certain varieties of mental disease—notably melancholia—it is often of service, and in cerebral anæmia, in asthma, in inveterate insomnia, and in all functional uterine irregularities it should be employed *before, not after*, all other therapeutic agencies have been exhausted.

Franklinization in Conditions of Debility.

Effects upon Nutrition.

such an application a larger flow of blood to the part, with subsequent increase of temperature and general improvement in nutrition. If muscular contraction results, it acts in addition as an artificial gymnast, imitating natural muscular action in a way quite impossible to any agency but electricity. It is in cases where there is muscular response to it, but not to the will, that it is often of immense service, and it can then be replaced by no other remedy known to medicine. Need I say that in such cases its dosage is of importance; that only a certain amount of stimulation being needed, this may not be carried to the point of exhaustion, and that the application should not be continued for too long a time. From ten to twenty minutes for an entire application is usually sufficient. So much for the stimulant effects of electricity when administered under either of its forms in a series of intermittent "shocks."

Electricity as a Stimulant.

The Constant Current.

But we get a very different result when we employ a constant current—that is, a continuous stream of electricity without interruption or break in it, and without appreciable variation in its strength. One effect of the administration of such a flow of electricity is that of a sedative, for it possesses the most remarkable power in relieving pain. We have all heard of the benefit of the "constant current" in neuralgia, and it is worthy of its reputation, and will not disappoint us if we

administer it with the precautions noted in my last Lecture. (See foot-note, page 52.)*

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* In the treatment of *Neuralgia* by the constant current the electrodes should be so applied as to include between them the part or nerve affected—the number of cells the highest number that can be borne without pain, *i.e.*, the current to be distinctly but not painfully felt, both electrodes being immovable. Time, five to ten minutes. Frequency, as often as the attacks of pain recur. I am satisfied that in severe cases this rule of application is essential—that the influence of the current shall be maintained as much as may be in the irritable nerve during the intervals of pain. In one case under my care the patient was galvanized with benefit 27 times in the 24 hours; but in milder cases one or two applications daily will generally suffice. A weak current from two or three cells—the electrodes being applied to each temple for one or two minutes—will sometimes dissipate a severe headache. This soothing influence of the current is often useful in allaying Spasm, as, for example, in spasmodic torticollis. The current should be localized in the irritable muscles: and it is generally advisable to energetically Faradize their antagonists and to conjoin with the electrical treatment appropriate gymnastic exercises, alternating with periods of perfect rest. I may mention that the only recorded case of improvement in that remarkable condition of spasm first described by Hammond under the name of *Athetosis* resulted from the Voltaic current. The case was brought before the Medico-Chirurgical Society by Dr. Gowers, and is published in the 49th volume of their Transactions. The reader will find the subject of neuralgia very exhaustively considered in Dr. Anstie's work.† He quotes some extremely severe cases in which the effect of Electrization was to arrest the pain in a few sittings, and to procure a remission for several days or even weeks; and I have had several cases which I believe to have been as fairly cured as an ague fit may be said to be cured by quinine. Dr. Russell Reynolds also quotes the case of a patient, a lady, who for twenty years had suffered from an extremely severe neuralgia of the ophthalmic branch of the fifth nerve, which recurred daily and from which her health had greatly suffered. It was not only relieved but removed by a single application.

Electricity in Neuralgia.

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† "Neuralgia and the Diseases that resemble it." By Francis E. Anstie, M.D., &c. London: Macmillan and Co. 1871.

Electricity possesses an influence *sui generis*.

Electricity, then, according to its variety and method of administration, is both a stimulant and a sedative; but although these words may be used as convenient distinctive terms, there is no doubt that it is something more, and that it possesses an influence quite *sui generis*, dependent, perhaps, upon its modification of the natural state of the electricity of the human body. The Voltaic current enjoys a remarkable restorative power, for it has been found that its prolonged action upon a nerve immediately after death will preserve its irritability for a length of time, and that even in a dead nerve the lost irritability may be again established. Dr. Poore has particularly studied this restorative or refreshing effect of the Voltaic current, especially in its application to a class of diseases (termed by him "fatigue diseases"), and of which writer's cramp is a type, chiefly characterized by an intense feeling of fatigue upon any attempt being made to execute certain muscular movements. This tired feeling is at once removed by the application of the Voltaic current, either to the muscles affected or to their nerves, and this result Dr. Poore believes to be explained by an increase in the susceptibility of the muscles to the stimulus of the will. Be this as it may, such an application is often most comforting, and it is not unusual for the patient to experience immediate and most grateful relief, and to beg for its repeti-

Restorative power of Voltaic Current.

Electricity in Fatigue Diseases.

tion. Many electro-therapeutists will attribute this relief to the production of, as it is termed, a condition of electrotonus, about which, and its importance in electro-therapeutics, a great deal has been written and disputed. Electrotonus is simply a name given to signify the state of a nerve while it is being traversed by an artificial Voltaic current. The effects of such an application, of course, depend chiefly upon the power of the current. If sufficiently powerful complete functional destruction of the nerve would result, as by a lightning flash; and as the tension of electricity is greater at one pole than the other, we naturally, with currents of a certain strength, discover modifications of irritability in the nerve when specially influenced by either pole. The irritability is increased in the half nearest to the negative pole (Katelectrotonus), decreased in the half nearest to the negative pole (Anelectrotonus), and unchanged at a point midway between the two poles (point of indifference). The production of the general electrotonic state is of importance. I believe these lesser variations of anelectrotonus and katelectrotonus to be practically of little moment, and I advise you to disregard them in therapeutics.

Electrotonus.

The restorative effect of the Voltaic current is frequently of benefit in sexual weakness. In functional cases, the current may be applied to the

spine—positive pole to mid-dorsal region; negative well painted over lumbar twice daily for ten minutes upon getting up and going to bed. This treatment was adopted in the case of a gentleman, fifty years of age, who consulted me for gradual decrease of sexual power, ending in complete impotence. Six weeks' treatment resulted, the patient informed me, in the complete restoration of the normal function.

Impotence.

Very marked absorbent or resolvent effects are also exerted by the Voltaic current, and are probably chiefly due to its powerful chemical action, for a current of great strength will dissolve or destroy any animal tissue whatever. One application of this chemical action is found in the electrolysis of tumours; another in the coagulation of blood in aneurisms;* and a third in the removal

Electrolysis of Tumours.

* Electrolysis is, of course, chiefly applicable to tumours which, from their nature or situation, are difficult or impossible to be removed by the knife; and, perhaps, also to malignant tumours; for whether or not the Voltaic current exerts a special destructive influence upon diseased germs, it seems certainly proved that there is a less frequent return of cancerous growths removed by its agency than by ordinary operative procedures or by caustics.

This treatment of malignant tumours by electrolysis is yet *sub judice*, but the evidence in its favour has recently much accumulated, and its full and exhaustive trial by competent observers possessing the opportunities of large hospital practice ought not to be much longer delayed. Neftel, of New York, who is its chief advocate, contends that malignant tumours are at first entirely local, and he explains their recurrence, after removal by the knife, from the fact of the impossibility of the whole of the diseased mass being excised, as apparently healthy parts when microscopically examined show that they have already become

or absorption of gouty and rheumatic deposits. In Rheumatic Gout, Dr. Poore has recorded a very successful result from the use of localized galvani- Rheumatic Gout.

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infected. Electrolysis he considers acts not only on the tumour but also on the surrounding tissues, the current being diffused to some distance in all directions. After electrolysis he applies a mild and not painful current for from a quarter to half an hour daily to the *locus morbi*, and continues this for some months. In one of his cases a mammary tumour existed of the size of a small orange. Three needles, from the negative pole of thirty-five cells, were inserted for half an hour under chloroform, and the operation was repeated thrice at intervals of a week, daily external galvanization being also used. The tumour gradually became smaller, and at last disappeared, but external treatment was continued for several months. At the end of a year there had been no relapse. In another case, in which the tumour had been excised by Marion Sims, it reappeared, and was again removed by the same surgeon, and pronounced cancerous. It again reappeared and was then electrolyzed, upon three occasions, by two, three, and four needles respectively, and with a current gradually increased from ten to thirty cells. The tumour by degrees grew less, and in three months was entirely dispersed; while, when the patient died from another disease three years afterwards, there had been no recurrence. Electrolysis of Malignant Tumours.

Electrolysis has been successfully employed in several cases of aneurism. Where pressure and ligature admit of application, it is hardly necessary to say that the preference should be given to them; but many internal aneurisms, and especially aortic aneurisms, cannot be thus treated, and in such cases the question of electro-puncture should be carefully considered, and, when called for, it should not be too long delayed. Two fine, sharp, and carefully insulated needles, one connected with each pole, should be introduced into the aneurismal sac, and the current allowed to pass for from half an hour to an hour, the needles carefully withdrawn, and their punctures covered with a bit of lint soaked in collodion or styptic colloid. Authorities are divided as to the kinds of aneurism calculated for electro-puncture, but there is no doubt than an aneurism pressing on the parietes, but not having actually perforated them, is the best adapted for this treatment, and that it is contra-indicated where the sac is of large size, or where large trunks issue from it. Aneurismal Electro-puncture.

zation. The disease had existed for three months, but the severity of the pain had much diminished, excepting towards evening, when exacerbations occurred. The wrist was considerably swollen, and absolutely stiff, the hand pronated and could not be supinated, and the hand and fingers were immensely swollen, so as completely to obscure their anatomy, while the fingers were extended, stiff, pale, and cold, and the nutrition of the entire limb impaired. The whole limb, and especially the hand, was thoroughly sponged with the negative pole, the positive being held in the patient's other hand. After the third application the swelling rapidly subsided, and in about a fortnight the hand, although still stiff, had resumed its natural aspect. The muscles were then faradized and shampooed.

Rheumatic Arthritis.

Rheumatic arthritis with nodosities is best treated by passing as strong a Voltaic current as the patient will submit to through each swollen joint for a few minutes, the direction of the current being frequently changed by the movement of the commutator of the poles.

Muscular Rheumatism.

The pains of muscular rheumatism are almost invariably removed or mitigated by cutaneous faradization, and so rapidly as in many cases to appear marvellous. In cases that had resisted all other treatment, an instantaneous cure has resulted, and sufferers whose pain has for a long

time obliged them to keep the arm immovable have been able directly after the faradization to execute any movement with ease. With these rheumatic patients it is especially of importance that the current should be strictly limited to the skin, carefully dried and powdered, and should *produce no muscular contraction*, or the suffering will be aggravated instead of relieved. Begin with a current readily bearable on your own hand, and increase afterwards. The above remarks are applicable to all varieties of muscular rheumatism, but not to arthritic disease.

General effects of Electrization.

So much for the general effects of electricity. All the structures of the body respond to its application; the muscles and motor nerves, as we have seen, by contraction; the nerves of common sensation by a burning or pricking; and of the nerves of special sense; the retina by a flash of light; the auditory nerve by a sound; the olfactory nerve by a peculiar smell; and the gustatory by a metallic taste, differing at the two poles. The action of the Voltaic current upon the brain is exceedingly powerful, and the greatest care must be exercised when it is applied to any part of the head or face. Not more than two or three cells should be commenced with. Its effect should be noted, and any increase should be made gradually. With a very moderate current giddiness is produced, and upon the sudden application of a

sufficiently powerful one the patient falls down as if struck by a blow.

General Debility.

All, or some of the more or less generalized applications, such as Beard and Rockwell's generalized electrization, the common Faradaic and Voltaic Baths, or Radcliffe's Charge, are of occasional benefit in conditions of general debility, and where general stimulation of the nervous centres is indicated. The electric bath is an elegant and pleasant mode of administering electricity, but it is less generally beneficial (except in certain gouty or rheumatic cases) than localized applications of electricity. The statement that metallic poisons can be eliminated from the body by its agency has not yet been established.

Paralysis.

There are very few, I think I may almost say not one, of the many disorders classed under the heading of paralysis, in which at some time or other of their progress some form of electrization is not essential to their most successful treatment. Where powerless to cure it will not unfrequently relieve the most distressing symptoms. Cases of functional paralysis from slight pressure are not uncommon, when power may usually be restored by a few Faradizations; but in paralysis from severe central or peripheral lesion progress must of necessity be slow. Such cases, regarded electrically, may be most conveniently considered under the two divisions of atrophic and non-atrophic

paralysis. In the great majority of atrophic cases there will be found abolition or modification of the normal electrical reaction of nerve and muscle, but whether this is so or not, in all cases of loss of power, in which any muscular wasting is visible, the localization of electricity in the wasting muscles is *imperative*, and in some varieties it is the only treatment which will arrest the disease. It is in these latter cases that its early administration is called for, before the degeneration and disappearance of the muscular tissue, and its early and judicious use will not seldom save the sufferer from being left for life with a powerless, or withered and deformed, limb. As an illustration, let us review the progress of a case of essential infantile paralysis, the most common of the paralyses of children; that form in which premonitory symptoms are often absent, or but slight, and where there is no rigidity. Very shortly after its onset, usually within a few days, the limb is found to be colder than its fellow, and its muscles to be rapidly wasting; the final result, if untreated, being the entire disappearance of some of them and the production of deformity. In fact, the larger number of cases of club-foot and analogous distortions are brought about by neglected infantile paralysis, and there is no doubt that by judicious treatment, of which early electrization is the foundation, the majority of them might have

Atrophic Paralysis.

Infantile Paralysis.

Infantile Paralysis.

been prevented. The leading orthopædic surgeons are fully alive to this fact, but they are powerless, as they are rarely consulted until all the mischief has resulted. The early recognition and appropriate treatment of these cases must continue in the hands of the family practitioner, and he must decide whether or not they are to continue, as at present is unfortunately too commonly the case, without any serious attempts at restorative treatment until commencing deformity compels attention to them. As soon as the medical attendant is summoned—and this is frequently only because the parents have noticed that the child is lame—he should carefully examine the muscles electrically, and unless there are head symptoms present, and this is very seldom, he should electrize each muscle daily with that current to which it responds, and of a strength just sufficient to produce muscular contraction. If the powerless muscles have preserved their Farado-contractility it may be confidently predicted that they will rapidly recover; but it will almost invariably be found that while Farado-contractility is diminished or abolished, there is increased response to the interrupted Voltaic current. They should be treated then with this current alone. Hot spongings and shampooings should also be employed, and it is of great importance that in the intervals of treatment the temperature of the affected muscles should be maintained at as high a degree

Importance of early Electrical Treatment.

as possible. If the leg is affected, a stocking of pure spun silk should be constantly worn, day and night, in addition to the ordinary clothing; if the arm, a silken sleeve. Infantile Paralysis.

When in any form of paralysis ANY amount of voluntary power has been restored by electricity, it is most important that the patient should be encouraged to use the limb and practise various movements. Passive movements are of equal importance, and the paralyzed muscles should be frequently exercised by this mode to the fullest extent of their normal movements. For example, if the extensors of the hand and fingers are paralyzed, the hand and fingers should be passively flexed and extended completely, at intervals of a few seconds, for some minutes, and so on with all the paralyzed muscles in succession. As soon as there is return of reaction to Faradization, Faradization should be alone used, and the rule in all cases of localized muscular electrization, muscular contraction being sought, is to use that current to which the muscles respond, and *I do not know of any exception to this rule;* but a successful result in severe cases of atrophic—not alone infantile paralysis, but all varieties of atrophic paralysis—is brought about by painstaking, daily, tedious, uninteresting treatment, with no chance of brilliant or rapid results, but which if thoroughly, faithfully, and patiently carried out, will reward us by progressive improvement, and sometimes—even in

Importance of active and passive movements in Paralysis.

Rule for Muscular Electrization.

cases regarded not long ago as quite hopeless—complete recovery.

Rigid form of Infantile Paralysis.

There are certain forms of paralysis affecting children where the muscles are rigid. Localization of any form of electricity in these rigid muscles is quite useless; but if these cases depend upon adhesions or exudations into the medulla their absorption may possibly be promoted by localizing a Voltaic current in the superior cervical ganglia of the sympathetic; two small conductors, leather, tipped and well-moistened in connection with the poles of a Voltaic battery being applied for four or five minutes to the bottom of the auriculo-maxillary fossæ on both sides. There seems no doubt that such an application causes a dilatation of the blood-vessels of the base of the brain, and is likely therefore to promote absorption.

Traumatic Paralysis.

In all cases of traumatic lesion—as by section of a nerve—the paralysis is atrophic, and the treatment I have recommended in infantile paralysis should be assiduously employed. Mitchell, of Philadelphia, whose experience of military surgery is unrivalled, commences electrical treatment and shampooing within a fortnight of the wound, unless there are special circumstances to contra-indicate it. Lead palsy requires similar treatment; so does, perhaps, the commonest form of peripheral palsy—facial palsy from neuritis of the facial nerve. In electrizing the facial muscles there is one caution necessary—especially to ob-

serve the rule of electrizing the muscles equally—for I have several times met with a contraction resulting from a too energetic Faradization of some individual facial muscle, to the neglect of the group with which it is in correlative action. Such a contraction may sometimes be removed by localizing in it for about five minutes a constant Voltaic current from eight or ten cells; but in the most favourable cases an unnatural expression of countenance will generally persist for a long time, from the non-recovery by the muscles of their perfect "tone," that quality which imprints upon each face its characteristic features, and which has been called the "Gymnast of the Soul." Caution necessary in Electrizing Facial Muscles.

In that most distressing disease, Cruveilhier's atrophy or wasting palsy, medication is altogether useless, and our one hope—not invariably a forlorn one—is in electricity. Localized Faradization to the muscles, alternately with Radcliffe's Positive Charge, together with galvanization of the sympathetic or of the spinal cord, admit of trial. Wasting Palsy.

In non-atrophic paralysis—of which hemiplegia may be taken as a type—the propriety of electrization, and especially the proper moment for its application, requires careful consideration. In both brain and spinal cord disease muscular electrization is not advisable until some time after the attack, or until the muscles exhibit signs of impairment of nutrition from disuse. As long as there is rigidity—especially with increased Hemiplegia.

Hemiplegia.

reflex action—any stimulant application of electricity is not likely to do good, and may do harm; but in older cases—both hemiplegic and paraplegic—cases of from six to eighteen months' duration—the immediate benefit to be derived from localized electrization is often remarkable, especially in those cases where, after a partial return of voluntary movement, the patient suddenly stops short, and for weeks or months makes no progress. As the sequel of electrization, the hemiplegic patient able to use the arm slightly, but not to feed himself, may regain this power, to his infinite comfort, and the paraplegic patient, able with difficulty to drag himself along by crutches, is enabled to walk by the aid of a stick. Some improvement is usually soon obtained, and it is progressive for, perhaps, two or three months, after which continued electrization fails to increase it; but at a subsequent period—six months afterwards—a renewed electrization may give rise to a new improvement; but be this as it may, whenever in these old-standing cases we see signs of impaired nutrition, it is wise to occasionally stimulate the muscles by Faradism. We should endeavour—in the words of the late Nestor of modern medicine, Sir Thomas Watson—"to preserve the muscular part of the locomotive apparatus in a state of health and readiness, until peradventure that part of the brain from which volition proceeds having recovered its functions, or

the road by which its messages travel having been repaired, the influence of the will shall again reach and reanimate the palsied limbs."* In hemiplegia the propriety of a direct application of the constant Voltaic current to the brain must be thoughtfully considered. In selected cases, where the clot or softening is of limited extent, its removal may be accelerated by a carefully localized current—two or three cells—for two or three minutes to the injured hemisphere, followed by Voltaization of the cervical sympathetic (so-called) for four or five minutes. After such an application there follows —according to Althaus—"greater ease in the head, as well as in the limbs, and if there has been pain this is relieved." Similarly the absorption of the inflammatory products may be promoted in the earlier stages of spinal disease, by localizing the Voltaic current in the parts affected, especially where pain is present, and

Direct application of Voltaic Current to Brain.

* The following is an illustrative case:—

A lady, forty-one years of age, had suffered from right hemiplegia for eighteen months, and described her condition as having remained without improvement for the past six months. She had recovered sufficiently to walk with the aid of a stick, but the movements of the arm were very weak, especially those of the deltoid, extensors of the fingers, and individual muscles of the hand. Faradic contractility was somewhat lowered, but there was no rigidity. The muscles were carefully Faradized with a current just sufficiently strong to produce their contraction. The entire application occupied about fifteen minutes, and was made once daily. After a fortnight's electrization she was able to raise the arm to a right angle with the body, and *to use the hand to feed herself*, neither of which had she been able to do before treatment.

we have reason to suppose that the myelitis is circumscribed. The daily application of the positive pole for about five minutes, and with from ten to fifteen cells, to the painful spot—the negative pole being held to an indifferent part of the body—is likely to promote absorption. At any rate it will sometimes relieve the pain. In the later stages of paraplegia, as soon as there is diminution of electro-irritability in the paralyzed muscles they should be sponged with the Voltaic current, or Faradized; and where anæsthesia is present, a good painting with the wire brush will often be of service. Paraplegic constipation may frequently be relieved by Faradization of the abdominal muscles, and the troublesome dribbling of urine, so often present, by external Faradization of the bladder—one pole to the pubes, and two sponges from the second pole—one to the sacrum and the other to the perineum. Incontinence of urine in children may be similarly treated. Cases of hysterical or emotional paralysis may frequently be benefited by the application of the wire brush, which also sometimes acts like a charm in removing anæsthesia, which, although originally of central origin, continues after the removal of its cause. Anæsthesia from section of a nerve is sometimes persistent in this way after repair of the nerve lesion. The wire brush is also useful in sometimes removing the anæsthesia present in locomotor ataxy, some cases

Electricity in Spinal Paraplegia.

Paraplegic Constipation.

Emotional Paralysis.

Locomotor Ataxy.

of which may be largely benefited also by the constant current to the spine—one pole to nape of neck, and the other to the lower lumbar vertebræ.*

Electricity is coming into use in mental diseases. Faradism, and especially cutaneous irritation with the wire brush, would seem to be most suitable for cases accompanied by depression or torpor, the stimulating effects being of service in inspiriting the patient, while the soothing influence of a direct application of the *constant* Voltaic current to the brain may be employed in cases of over-excitement requiring a sedative.

Electricity in Mental Diseases.

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* The following is an extract from Dr. Sturge's Report of the results of treatment at the National Hospital for the Paralyzed and Epileptic:—

"In the division of Muscular Atrophies some striking cases have occurred, and in all of these the improvement is mainly due to the electrical treatment prescribed.

"A patient, with atrophy of some of the muscles of both arms of six months' standing, which incapacitated her from dressing herself or cutting her food, or doing much household work, was discharged at the end of three and a half months, able to feed and dress herself, sew, and perform almost any domestic duty.

"Another woman, with atrophy of the muscles of the forearm of several years' standing, and who was similarly incapacitated from almost all use of the hands, went out, after a month's treatment, able to dress and feed herself, and to perform many actions that were before impossible for her.

"A man came to the hospital with atrophy of many muscles in various parts of the body, more especially in the left arm, which he was unable to move from the side. He went out able to lift his arm well over his head, and with much increased strength in the limb.

"Another man, in a very similar condition, was also greatly benefited; and whereas on admission he could barely bend the right arm at the elbow, after three months' treatment he was able to use a hammer with the arm."

Diseases of Women.

It is remarkable that electricity should have been so little used in this country in the diseases of women. According to Golding Bird, it is the only true emmenagogue that we possess. Be this as it may, all of its forms are serviceable in stimulating the secretions, and may be employed with success in cases of suppression of the catamenia from a torpid condition of the uterine organs. A generalized application will often suffice. Let the patient sit with her feet in tepid salt and water, in which is immersed a wire from one of the poles of an induction instrument in action, while a large sponge from the other pole is held applied to the lumbar region. Strength of current as much as she will bear. Time, ten to fifteen minutes. The application should be made twice daily for the three or four days preceding the usual catamenial period. If this method fails in its object, direct electrization must be resorted to; but Franklinization most often succeeds.

Electricity as an Emmenagogue.

On the Continent electricity has been largely employed in the treatment of inertia uteri in the second stage of labour, also in producing premature labour; in the resuscitation of still-born children, and in uterine displacements. We possess other remedies for these conditions, but in labour its advantages over the administration of ergot, include the rapidity and certainty of its action, the exactness with which its dose can be regulated, and the strength and regularity of the

The Advantages of Electrization over Ergot.

contractions which it produces. It admits also of being used in extreme cases in which the power of swallowing has been lost, or where everything is rejected from the stomach, while it never exerts in any way—as ergot is said to do occasionally—any injurious effect upon the new-born child.

Faradization in Post-partum Hæmorrhage.

Gentlemen, it is my firm belief that if a Faradaic instrument were at hand, and properly used, there would never be another death from *post-partum* hæmorrhage. The Faradaic current, thoroughly localized in the uterus, will always produce its contraction, not only while life persists, but even for a limited time after death, but failure in localizing electricity in an organ, withdrawn from sight and covered with thick muscular tissue, is especially liable to occur, unless the details of application are conducted with extreme care. Assume the case to be an example of severe *post-partum* hæmorrhage, that the ordinary resources of medicine have failed the obstetrician, and that he fears every moment may be his patient's last, but he has an induction instrument at hand. Let him waste no time, but at once introduce his right hand into the cavity of the uterus and grasp in his left the moistened sponge attached to one of the conductors of the instrument in action. Let an attendant, holding by its insulating handle the conductor from the other pole (which should be a well-moistened sponge) thoroughly paint with it, as it were, the abdominal parietes, pressing it with

considerable force against the practitioner's hand, and afterwards apply it to the lumbar region. *Contraction of the uterus will invariably result if the current used be of sufficient power.*

Uterine Neuralgia.

Sterility.

In my own hands an intractable case of uterine neuralgia was perfectly cured by the Voltaic current; and I have knowledge of a case of sterility which the localization of the Voltaic and Faradaic currents alternately would seem to have removed. One conductor was applied to the os, and two sponges from the second pole—one to the position of each ovary. The applications were made thrice a week for a fortnight before each menstrual period, and for a period of four months. Conception followed, and the patient, who had been married for thirteen years, in due course gave birth to her first child.

Paralysis of Nerves of Special Sense.

The stimulant effects of electricity are occasionally beneficial in the treatment of paralysis of the nerves of special sense, especially of the optic and auditory nerves, while its use has been advocated in a multitude of diseases to which I shall not further refer, than by saying that a clear comprehension of the principles of electro-therapeutics will prevent the occurrence of difficulty in any special application of them; and let us shortly recapitulate the most important of these principles.

Résumé of general principles of Electro-therapeutics.

We have seen that electricity is a stimulant, a sedative, a restorative, and an absorbent. Its stimulant properties are chiefly of use in diseases

Résumé of general principles of Electro-therapeutics.

of debility, and notably in paralysis—its sedative properties in the alleviation and removal of pain and spasm, and notably in neuralgia—its restorative properties in fatigue diseases, notably writer's cramp—and its absorbent properties in exudation diseases, and notably in gout and rheumatism. The dose of electricity consists of the addition of two factors—firstly, the strength of the current, whether Voltaic or Faradaic; secondly, its duration. It is of essential importance that we do not overdose our patient, but we are little likely to do this if we adhere to the two cardinal rules—to use the *minimum* power which will produce the results we desire, and not to unduly prolong our application: and really this question of "dosage" forces us to consider how far it is advisable for the medical practitioner who prescribes electricity to sanction its administration by the patients themselves. While there is no doubt that the most explicit directions will often be misunderstood, or fail in being correctly carried out, yet it would be practically impossible (to say nothing of the expense to the patient) for any medical man to himself apply electricity daily for a lengthened period; and we are compelled, in certain cases, to do our best in instructing *some one attendant of the patient* how to carry out the treatment, making her do this a few times in our presence, *and looking sharply after her afterwards*, and in addition explaining everything as fully as possible to the

Résumé of general principles of Electro-therapeutics.

patient, or the patient's friends. Moreover, we must not lose sight of the fact that, with electricity as with other remedies, the skill of the physician is shown in determining how, when, and in what dose to administer it, and his judgment in selecting those cases in which its administration may be wisely committed to others.

In conclusion, Gentlemen, allow me to thank you for the attention with which you have listened to these imperfect Lectures. I fear that I have failed in doing full justice to their subject; but I trust that I have succeeded in indicating the importance of electricity, as a supplement to, not as a substitute for, the more ordinary resources of therapeutics: in removing any doubt as to the class of cases calling for its employment; in supplying any want of information regarding details of its application; and especially in proving its claim to be more fully employed in your daily practice. A theoretical belief in its efficacy is widespread in our profession, its *frequent use* is yet in the future, but I hope a not distant future. Gentlemen, with you rests the decision whether this shall or shall not be. You will decide it not by the dictum of any specialist, but by the general voice of the profession, declaring your verdict as founded alone on your own personal experience.

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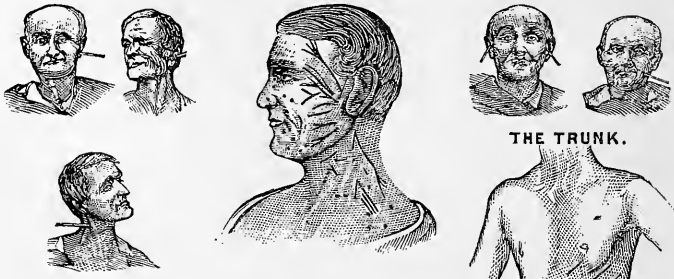

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TO USE THE GALVANIC CURRENT.

To use the galvanic current place the ends of the conducting cords in the two binding posts mark **13—13**. Place the socket of current selector (**20**) on the pin marked O, and turn the lever of selector on pin No. **1**, or on any number, according to the number of cells desired ; at the same time see that all the switch levers are on their blank buttons, except the one at left of current selector, which should be on its left-hand qutton marked Constant.

If it is desired to use cells from any other part of the series, place the socket on the pin from which it is desired to begin, and having previously moved the lever ahead of this pin move it along until the desired number of cells intervenes between socket and lever. The number of cells in circuit when the socket is not on O, but on a pin with a number, is the difference between the number of the pin and number on which the lever rests, for instance, if socket is on pin **12** and lever on pin **22**, then **10** cells are being used, the starting point being **12** cells from any part of the series may thus be brought into the circuit. If socket be placed on pin **39** and lever on pin **40** then the **40**th cell would be in use only.

Always keep the socket on the lowest number and the lever on the highest, as putting socket ahead of lever would reverse the current

Should, through any accident, a cell become disconnected or run down, or should it get out of order from any cause, it is only necessary to short-circuit the cells and throw the milli-ampere-meter in circuit by adjusting the switch **10**. By placing the socket on the pin marked O and selecting cell after cell with the lever, the defective cell is easily found by the milli-ampere-meter failing to deflect when the pin corresponding to the defect is reached.

TO OBTAIN THE INTERRUPTED GALVANIC CURRENT.

To obtain the interrupted galvanic current, move the switch at left of selector on to button marked interrupted, then turn the switch just above the vibrator on to its button marked **11**, by adjusting the screws at **14** and **15** the proper degree of vibration will be obtained. It is necessary that the point of the screws at **15** should touch the plate with every vibration as the current passes through at this point and unless it touches, connections would not be made.

TO MEASURE THE RESISTANCE OF THE PATIENT.

To measure the resistance of the patient turn the lever at the left of selector on to the button **8** marked milli-amperemeter and wire rheostat. Supposing him to have the electrodes in his hands and a current from **30** cells registers **8** milli-amperes; without changing any other conditions, throw the upper left-hand lever **10** on button marked rheostat and milli-amperemeter only. The patient will now be thrown out and the needle will fly around as far as it can go.

Begin by throwing in resistance, which is done by manipulating the top row of levers, until the needle which will have retraced its course rests directly over the division marked **8** milli-amperes or whatever may have been the previously recorded amount. The numbers on uncovered buttons added together will be the resistance of the patient. The known resistance having taken the place of the patient.

The upper left-hand lever should at all times except for purposes of measuring the resistance of a patient. be kept on its blank button, or the battery will be short circuited and injured.

THE POLE CHANGER.

The pole changing lever above the two posts marked **13-13**, when pressed between the two right-hand springs makes the right-hand binding post positive, and when pressed between the two left-hand springs the left-hand post becomes positive and the right negative.

GRAPHITE RHEOSTAT.

When the left-hand lever is placed on button **9** it throws the graphiite rheostat (**16**) into circuit. To use the rheostat first draw up the rod (**17**). By slowly pressing the rod down through the graphite it gradually lessens the resistance thereby, increasing the current without shock to the patient. With this rheostat you can place any number of cells in the circuit.

THE DE WATTEVILLE SWITCH.

The de Watteville switch is placed directly above the pole changer is used for obtaining either the galvanic or the faracid current separately or the two combined. When the double lever rests on figure **1** and **3** the galvanic alone can be used; can when on **3** and **5** the faradic can be alone used and when on **2** and **4** the two currents are combined and used without changing the conducting cords.

THE FARADIC APPARATUS.

The Faradic apparatus of this cabinet combines a fast and slow interrupter also a single contact key. The style of coil used is the Du Bois-Raymond. To use **Primary** coil, place the two tips on ends of conducting cords into the two binding posts in front of the coil, the others being connected with any desired electrodes. The strength is increased by drawing the coil to the **Right,** first placing switch at right end of coil on button marked P.

To use the secondary coil remove the tips of cords from primary posts: then place the ends of cords in the two binding posts **13-13** and place switch on right end of coil on button marked **S**. To increase the strength of secondary, push coil to the **Left** gradually, which is just **Opposite** to what is done in case of primary current.

THE USE OF THE INTERRUPTER.

To use the rapid interrupter which works against the end of core it is only necessary to adjust the screw F, and any degree of vibration may be obtained. The same may be said of the slow interrupter which is adjusted by the screw D, but it is further controlled by the sliding weight at E. By sliding the weight up and down the interruptions are varied from very slow to rapid.

The higher the weight the slower the interruptions and vice-versa. At button G, is the "single contact" used in obtaining single impulse contractions.

The different interrupters may be placed in circuit by a switch on the base of the Cabinet which works over a series of buttons marked S., F and C which put in operation the slow, fast or single contact interrupters, as desired.

DIRECTIONS FOR CONNECTING CELLS.

Fill the cells according to the directions on the cell label, and connect the wires of the cable to the cells, as shown in the cut; No. O being attached to zinc of the first cell, No. **1** to the carbon of the first cell, while at the same time the carbon of the first cell connected to the zinc of the second cell by strip from the carbon of cell, No. **2** wire of the cable to the carbon of the second cell, and so on, the last wire being connected to the carbon of the last cell, as shown by No. **40**. The two wires marked faradic should be connected as shown, the four cells being placed in two rows of two each, the zincs and carbons being connected together as shown in diagram.